severe loss of chord length at about 0.165" at the GE location. This unit had the best back pressure (lowest value) and that is reflected in the more intensive erosion.
Bill Hansen

*** SUBCASE 20080507-0244-1 CREATED 05/09/2008 04:39:21 PM hansenwi
Hello STT;
Could we ask your group's opinion on this miosture erosion data that has been accumulated for this unit's 3 LPTs exhaust L-0 stages?
Bill Hansen

*** SUBCASE 20080507-0244-1 CLOSED 05/14/2008 04:01:21 PM emeterel
Engineering has review the erosion data submitted. The measured erosion data is in line with the expected erosion after 20 years service. Engineering does not understand the issue of less erosion in between 1.5? to 6? from tip. Those buckets are acceptable to operate for now. Engineering recommends closely monitoring bucket erosion in the future. It is recommended ordering some spare buckets in case the bucket replacements are required later.

*** EMAIL OUT 05/14/2008 05:11:11 PM hansenwi Action Type: External email
Send to: [cecil.james@ge.com]
Hello Cecil;
See Design Engrg's input /recommendations as to the Determined/documented erosion on these buckets. Engrg. feels the buckets are acceptable for further operation. The customer should review the erosion at the next convenient outage and plan on partial or full row replacement at a subsequent outage.
I'll issue resolution of the case.
Bill Hansen

*** NOTES 05/14/2008 05:11:57 PM hansenwi Action Type: Resolution Issued
Resolution is issued per the above notes.
Bill Hansen

*** EMAIL IN 05/16/2008 10:09:38 cecil.james@ge.com

Thanks for the info. The other deliverable is a relative comparison between their own erosion and other 30 " LSBs. If we have any erosion data from other plants w/30" I could use it to show IPP their erosion with others

*** EMAIL OUT 05/19/2008 03:19:04 PM hansenwi Action Type: External email
Send to: [cecil.james@ge.com]
Hello Cecil;
The comparison of moidture erosion between units is not simple There has not been any standard thorough means of trackng moisture erosion on exhaust buket rows. Therefore there is no "library" of the moisture erosion for these bucket rows for the field of owners. The moisture erosion varies from one machine to the next even with two units situated next to each other, We would need to ask the customer for the number of hours of operation that the LP turbine has seen with these buckets. The exhaust pressure would need to be a factor in the amount of exhaust end erosion as well so if there is any variation of condensor pressure for significant periods that should be known as well. If you can obtain that data from the customer we will ask Design Engrg. if this given erosion documented in the case is comparable to fleet units with these bucket exhaust ends. I will then ask Design Engrg. for an opinion on this question.
Bill Hansen

*** EMAIL IN 05/07/2008 14:12:15 cecil.james@ge.com
Customer requests expert interpretation of LSB TIL 1521 erosion measurements. Erosion was measured using GE's instrument and procedure. All data is attached for review and recommendations.
Customer also requests a comparison between their erosion and other plants who have and have not replaced their LSBs subsequent to measuring their own LSB erosion.

Desired Deliverable:
1. Recommendation on replacing the LSBs, i.e. whether replacement is needed and if so when. This turbine is scheduled for an overhaul in 2009, and no plans to open it again until 2016.
2. Comparison between IPP's erosion and other LSBs (preferably 30"), specifically those with failures.

PROFILE INFORMATION:
NAME: Cecil James
ADDRESS: 2180 South 1300 East
Suite 340 Salt Lake City, UT 84106 United States
PHONE: 801 468-5705
FAX: 801 468-5767
CELL PHONE: 801 560-2251
EMAIL ADDRESS: cecil.james@ge.com

The following attachmnts have been added to this case:
270T151 LSB Erosion Statistics.pdfIPP_LSB_Cord_Length_Calcs.pdfLSB erosion workbook.xls

*** EMAIL OUT 05/07/2008 09:14:13 PM hansenwi Action Type: External email
Send to: [cecil.james@ge.com]
Hello Cecil;
Themoisture erosion of the bucket inlet edges of exhaust stages is common as you know. There is no machines that are designed for the most optimum performance that do not utilize the highest exhaust end pressure drops to get the best heat rate and power output. The saturation point in the exhaust end (Wilson Line) then takes place at the L-1 or L-2 stage locations. The fluid then carries moisture particles moving at relatively slow axial velocities compared to the gaseous steam through the volume swept by the buckets. The moisture globules then become obsticals which impinge on the much faster moving inlet edges of the buckets. This causes a release of very high imploding energy which tears away the bucket metallic material at these locations. After millions of these impacts there is a marked loss of inlet edge material. The shape and recession of the inlet edges are what is being measured.
Methods of reducing the moisture erosion have been developed over years of experience with means of trial and error with techniques. One of the most successful has been the application of roled/wrought stellite erosion sheilds to the inlet edges. These are attached by welding or silver brazing techniques. Another technique is to flame harden the inlet edges of the buckets. These techniques have been very successful in reducing the damage caused by moisture erosion. A key to the success is that the edge are not just somewhat harder but are also much tougher. This is the resistance to the moisture erosin in that it takes very high energy levels to tear away the bucket material.
One phenomenum of the moisture ersion is that the eroded resultant peaks and valleys (on a macroscopic level) also improve the resistance of the inlet edges to further erosion. Therefore once the initial formation of these eroded surfaces is generated the rate of moisture erosion usually diminishes per unit time under identical subsequent operating conditions relative to LP Exhaust end operation. Therefore many rows of buckets will last many years after the initial rate of erosion which may be fairly rapid. This is why it is a very effective means of evaluating bucket life relative to MPE to record the erosion rate at every major STG shutdown/outage and spend the time to do it correctly.
The evaluation of the measurements taken and recoded can be made and recommendations made as to further operationa nd expected life predictions made as to failure of the buckets due to craks initiating in any of the crevices in the eroded inlet edges. Also history of the lifetime of identical bucket rows will enter into a Design Engrg. recommendation as to bucket life.
We will need to review the drawings for these bucket rows and the measurements made on the unit that have been recorded as to erosion magnitude and ask Design Engrg. for a recommendation and their input to this evaluation.
Bill Hansen .

*** EMAIL OUT 05/09/2008 04:36:33 PM hansenwi Action Type: External email
Send to: [cecil.james@ge.com]
Hello Cecil;
I'll create a subcase to Design Engrg. to ask them to give us an opinion on this erosion data as taken on this unit's L-0 bucket rows.
I added the view of one of the L-0 bucket rows, 837E930 which shows the tip, 3" and 6" in from the tip as locations of the most severe erosion as determined from the measurements taken. The data shows the LP "C" unit has the most

Dave Spence - Unit 2 LSB Erosion Analysis

From:	"James, Cecil (GE Infra, Energy)" <cecil.james@ge.com>
To:	<dave-s@ipsc.com>
Date:	5/31/2008 10:03 AM
Subject:	Unit 2 LSB Erosion Analysis
CC:	"John Alaksiewicz (John Alaksiewicz)" <john.alaksiewicz@ge.com>, "Auburger, Grant E (GE Infra, Energy)" <grant.auburger@ge.com>, "Robert Ruotsi (Robert Ruotsi)" <robert.ruotsi@ge.com>, "Mark Lundien (Mark Lundien)" <mark.lundien@ge.com>
Attachments:	270T151 LSB Erosion Statistics.ZIP

Dave,

I know you're waiting for this so I'm sending what I have:
<<270T151 LSB Erosion Statistics.ZIP>>
I've held onto this for a few days hoping to find other erosion measurements we could compare yours to, but I haven't found anything comparable. The one 'comparison' data I included here was taken from a Unit that had a LSB failure, but I really need to warn you about making any conclusions using the 'comparison' data. The inherent differences between yours and the 33.5" LSB are enough that we can't draw any correlation between erosion and life expectancy, i.e. the 33.5" LSB is approximately 3.5" longer than yours which gives it a much higher tip speed and the mass geometries at the tips are also different enough that it would differentiate problematic erosion thresholds. So, the 'comparison' erosion in this case is really only good for showing how your erosion is tracking relative to another unit that had an unfortunate LSB failure (i.e. tip liberation).

U1 outage report?

After John and I measured the Unit 2 LSBs last outage I ran a statistical analysis to confirm the data's reliability and then submitted the data to Schenectady for their review and recommendations. After reviewing the measurements, their conclusions have only subtle differences from the one in the outage report, which should be expected since our first opinion was based on less than optimal photos while the second opinion was based on precision measurements. Upon review of the measurements, Schenectady believes the buckets are trending similar to other buckets of same age, but recommends ordering spare buckets in case a replacement is needed in short order. They also recommend monitoring the buckets including the following:

- Perform mag particle test as convenient
- Visual inspections
- Measure erosion as convenient

These LSBs are acceptable for further operation, but to mitigate risks it is recommended to plan a row replacement during the next suitable outage. In your case - weighing the risks of an aging row of buckets and your LP section outages.

Look this over and let me know what else you may need.

Cecil

Cecil D. James PhD, P.E.
GE Energy
West Region Applications Engineer
Power Generation

T 801 468 5705
C 801 560 2251

IP7019451

D * 676 4705
F 801 468 5767
E cecil.james@ge.com
www.gepower.com

2180 South 1300 East, Suite 340
Salt Lake City, Utah 84106

General Electric Company

IPP, Unit 2 LSB Erosion (270T151)

April 7, 2008

TIL 1521, LSB Erosion

Descriptive Statistical Analysis

	Mean	Standard Deviation	Min.	Max	Median
LPA TE1	0.059	0.033	0.026	0.131	0.049
LPA TE2	0.117	0.011	0.085	0.120	0.120
LPA GE1	0.067	0.020	0.048	0.113	0.060
LPA GE2	0.054	0.015	0.040	0.092	0.050
Averages	0.074				0.070
LPB TE1	0.110	0.011	0.095	0.126	0.110
LPB TE2	0.121	0.021	0.093	0.160	0.126
LPB GE1	0.127	0.017	0.112	0.167	0.121
LPB GE2	0.103	0.021	0.084	0.149	0.093
Averages	0.115				0.112
LPC TE1	0.117	0.019	0.104	0.162	0.110
LPC TE2	0.113	0.016	0.099	0.146	0.106
LPC GE1	0.142	0.014	0.127	0.166	0.136
LPC GE2	0.134	0.018	0.114	0.165	0.129
Averages	0.126				0.120

Notes:

- Statistical erosion agrees with relative back pressure between hoods. I.e. LPA has highest BP and least statistical erosion while LPC has lowest BP and highest statistical erosion: LPA – 0.062, LPB – 0.115, LPC – 0.126
- Uniform erosion between ends within respective hoods (pg 6).

Two Sample T-Test and Confidence Interval

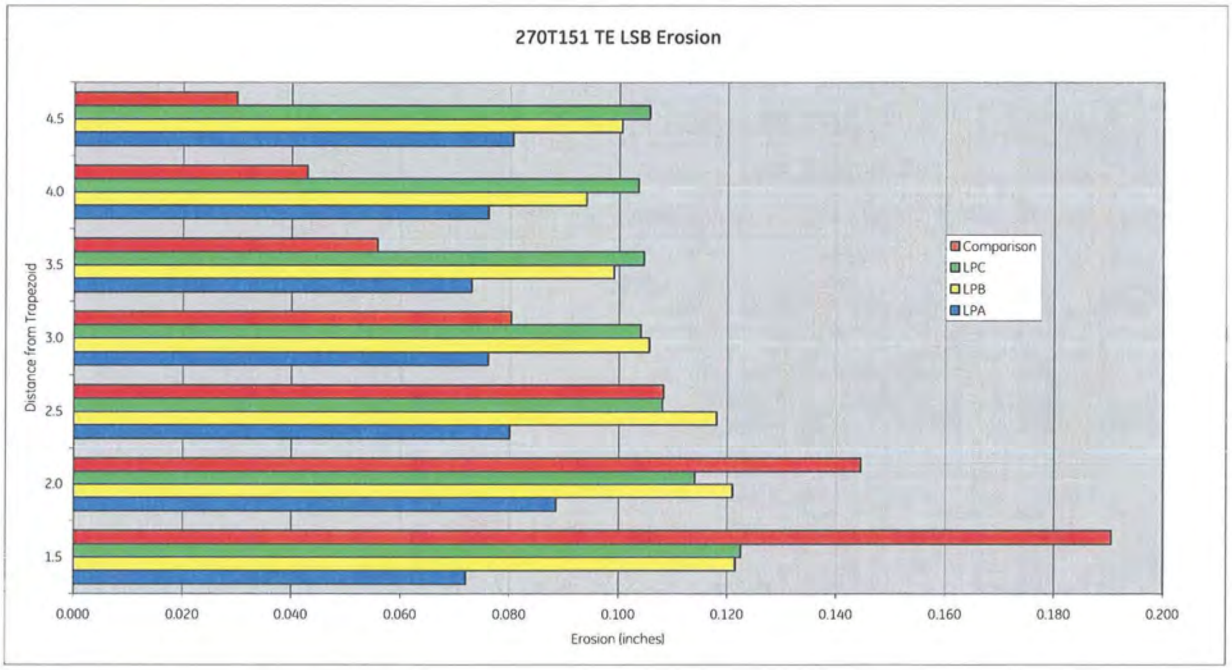
```
Two sample T for Erosion
End          N      Mean     StDev    SE Mean
GE          60    0.1043    0.0375    0.0048
TE          60    0.0981    0.0333    0.0043
95% CI for mu (GE) - mu (TE): ( -0.0066,  0.0191)
T-Test mu (GE) = mu (TE) (vs not =): T = 0.96  P = 0.34  DF = 116
Since P > 0.05 there is no statistically significant difference between sample means
```

- Atypical erosion pattern from tip to approximately 6 inches down from the tip. Greatest erosion occurring at the 1.5 inch and 6 inch measuring points and lesser erosion in between these two points.

IP7019453

IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

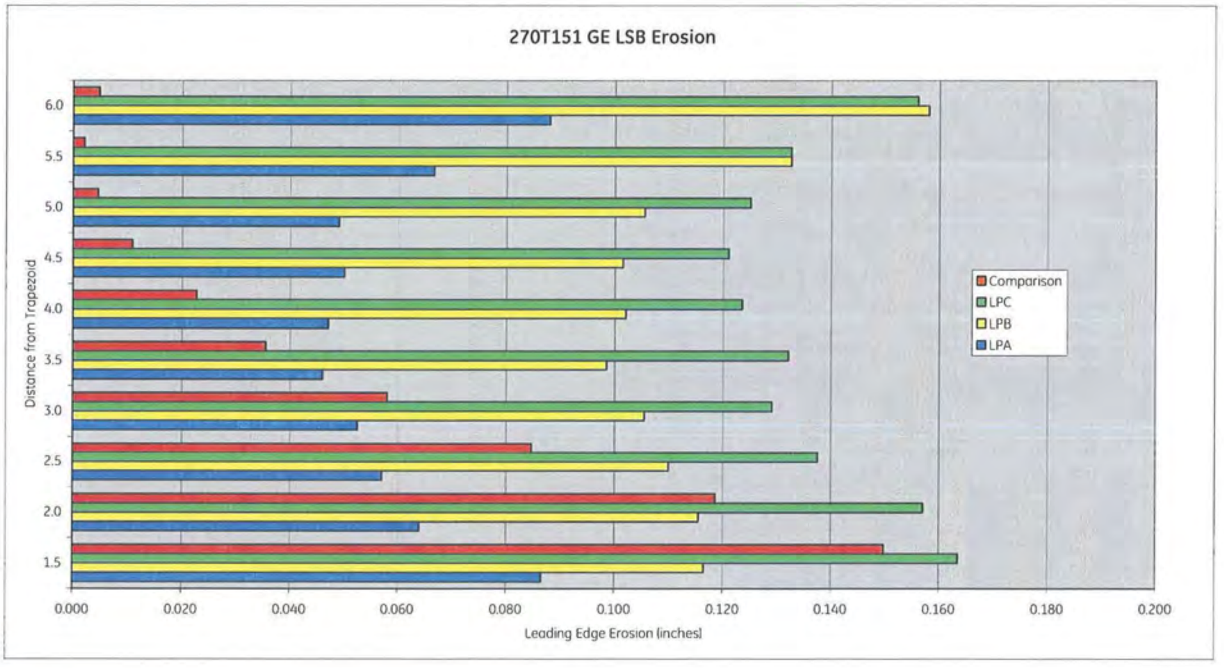
Comparison of IPP's erosion to erosion measured on a 33.5" D8 turbine where LSBs were replaced.



IP7019454

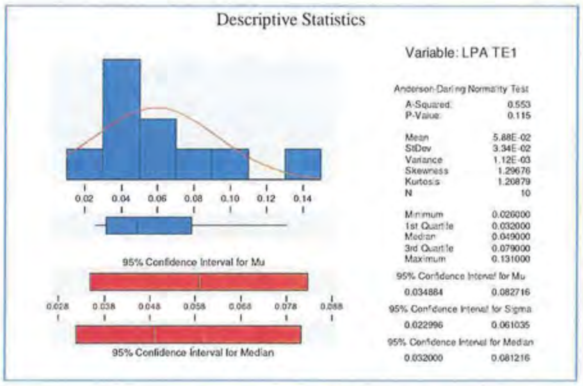
IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

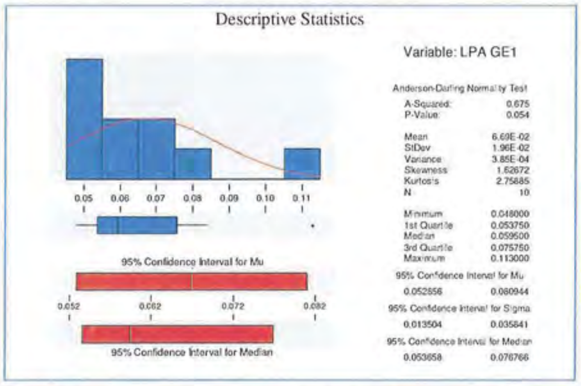
Comparison of IPP's erosion to erosion measured on a 33.5" D8 turbine where LSBs were replaced (continued).

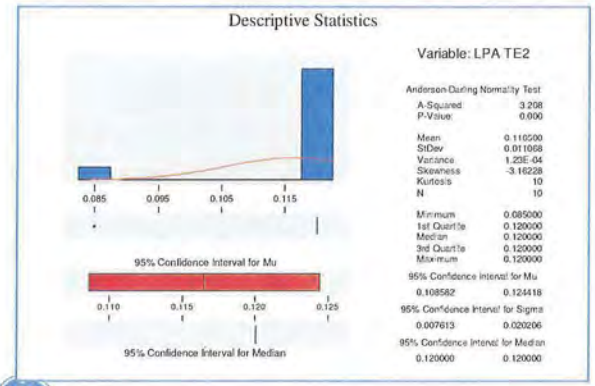


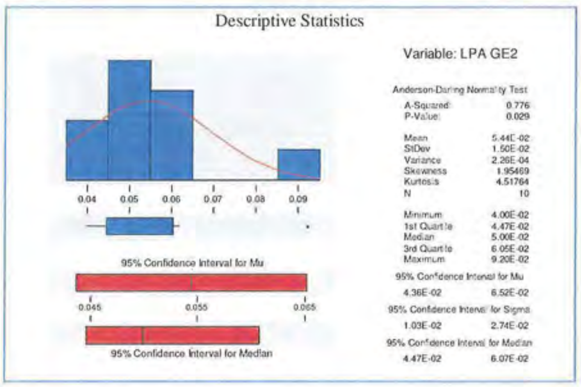
IP7019455

IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008



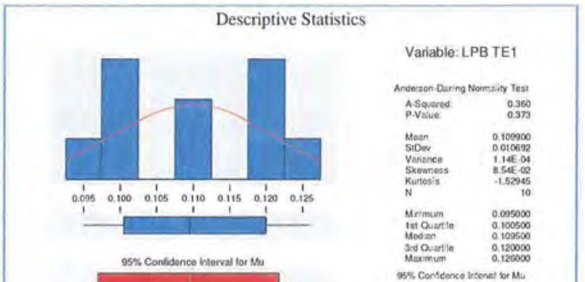


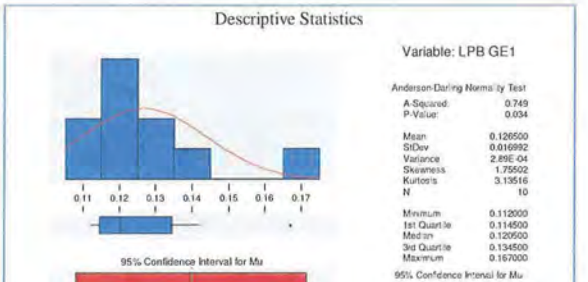


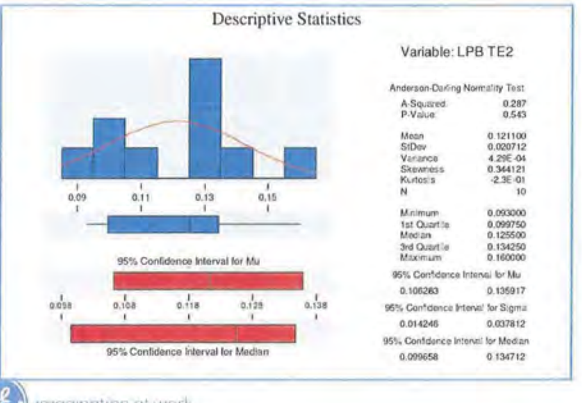


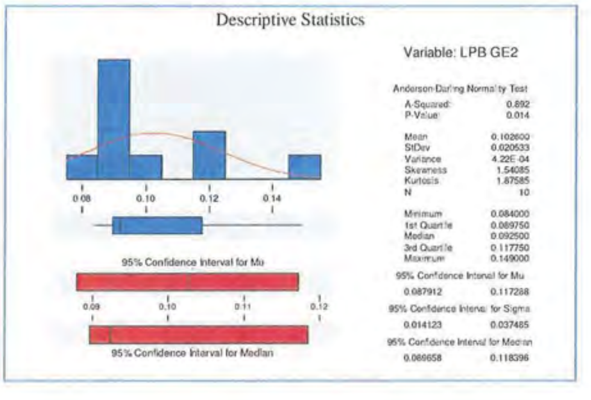
IP7019456

IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

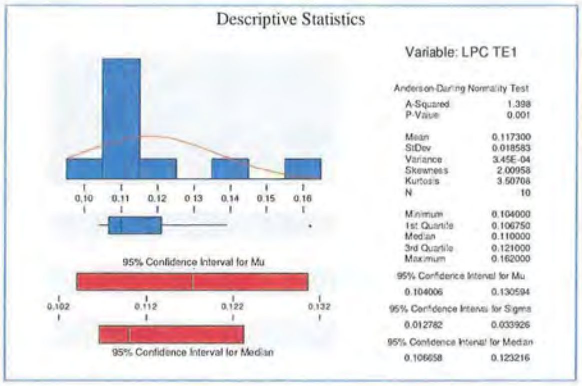


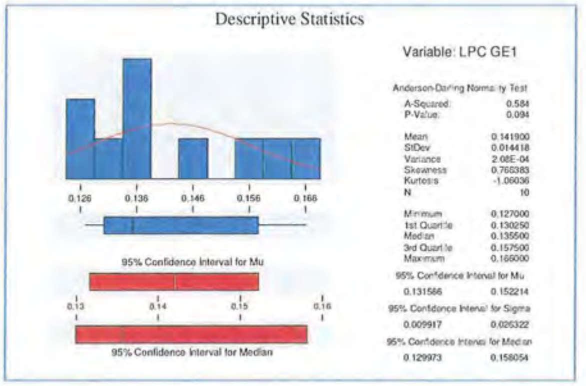


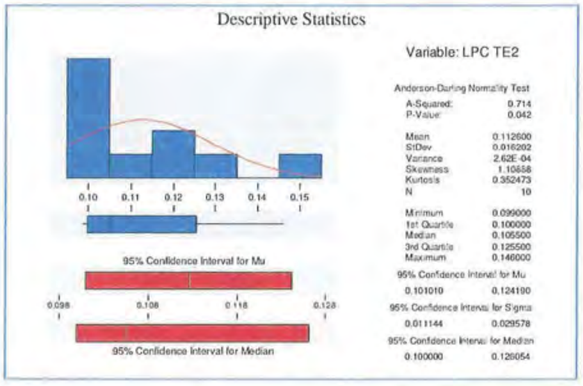


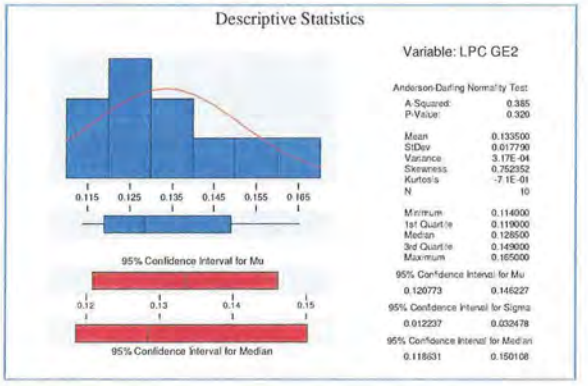


IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008





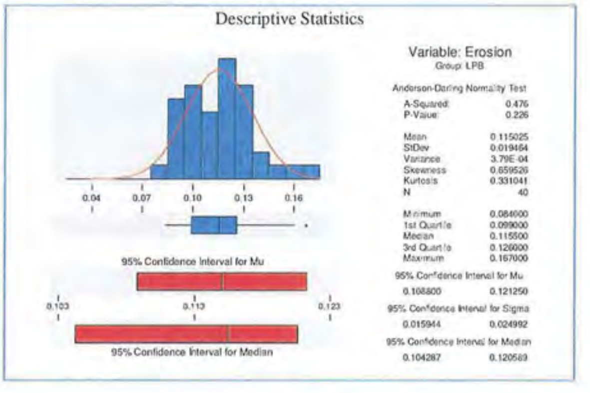


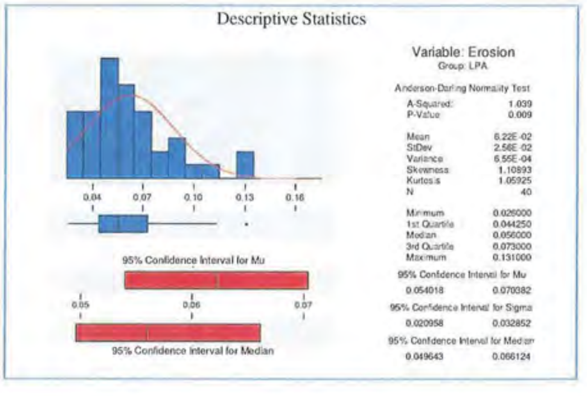


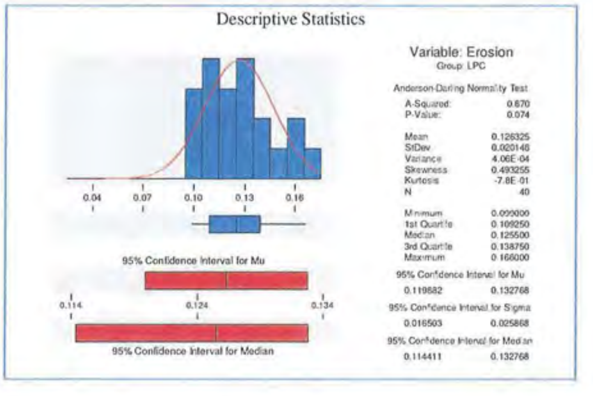
IP7019458

IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

Erosion by Section:



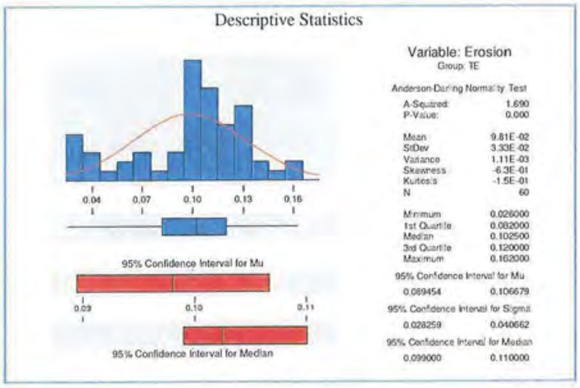




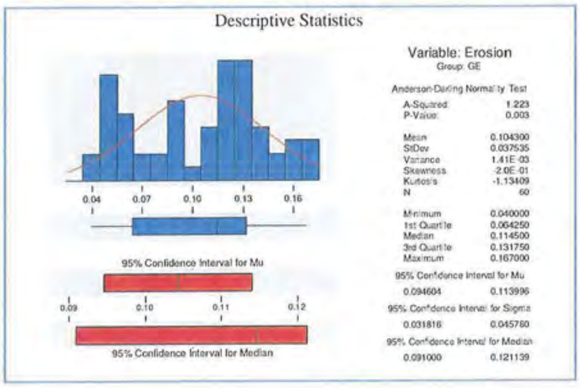
IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

Erosion by section end:

Turbine End:



Generator End:

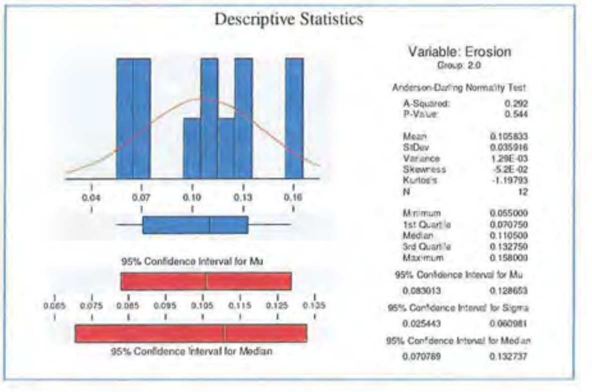


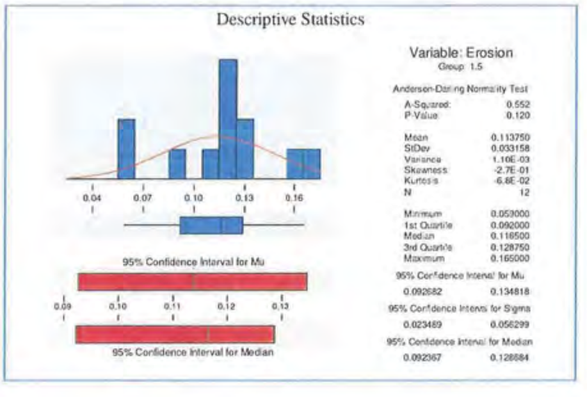
IP7019460

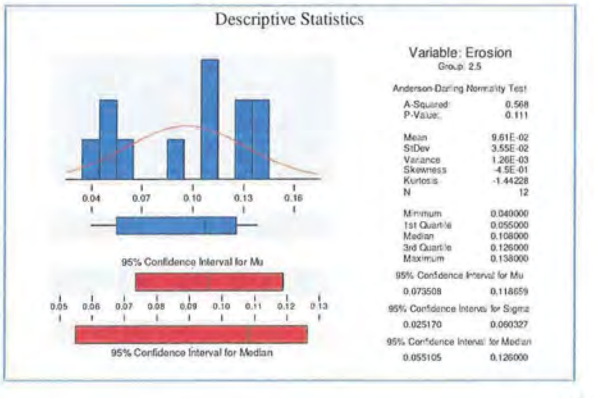
IPP, Unit 2 LSB Erosion (270T151)

April 7, 2008

Erosion by Distance from Trapezoid:



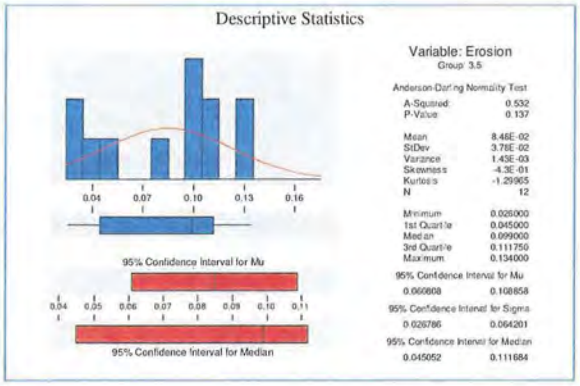


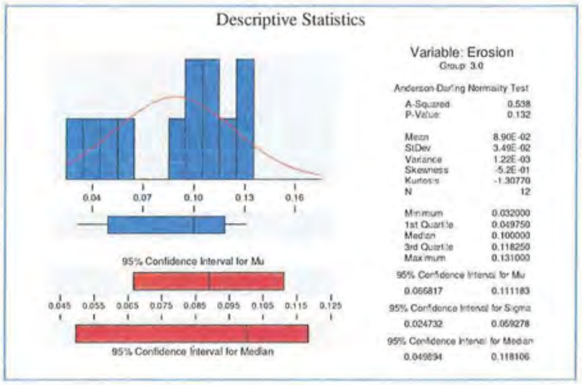


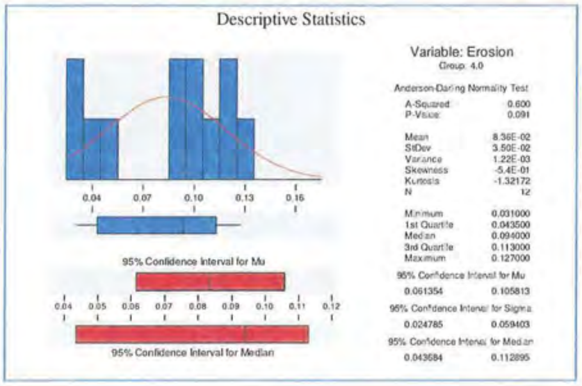
IP7019461

IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

Erosion by Distance from Trapezoid (cont.):

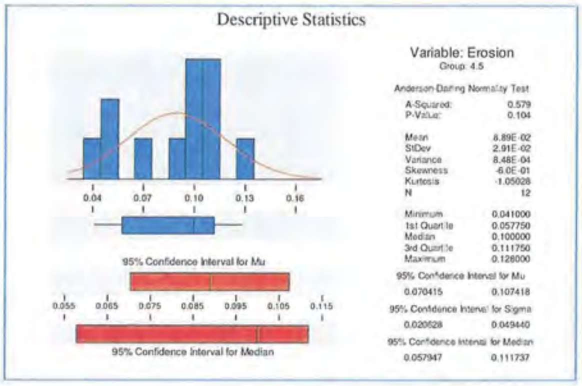


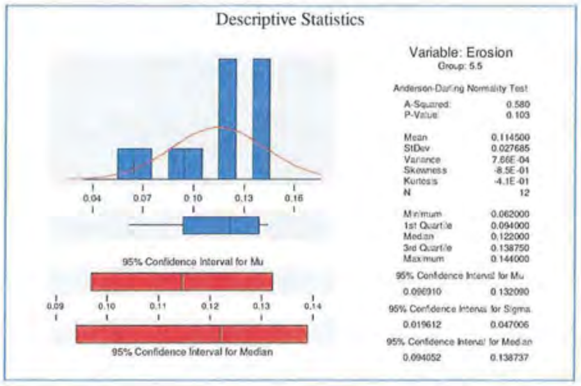


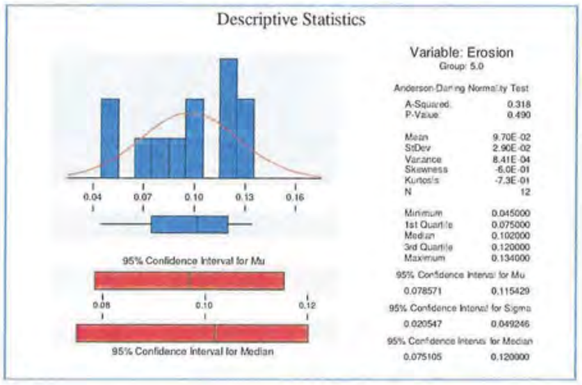


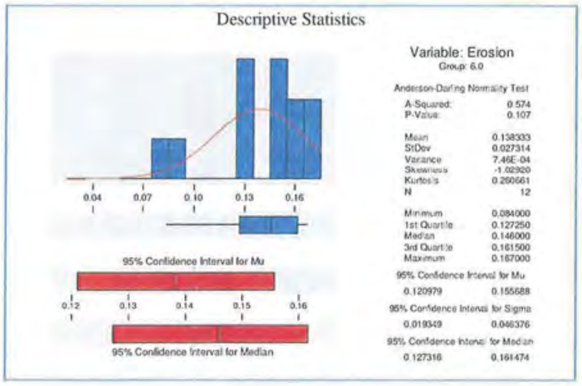
IP7019462

Erosion by Distance from Trapezoid (cont.):





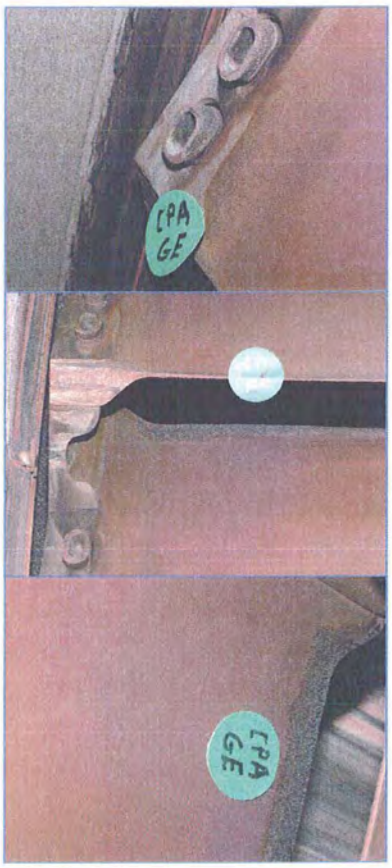




IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

LPA Photographs

Generator End



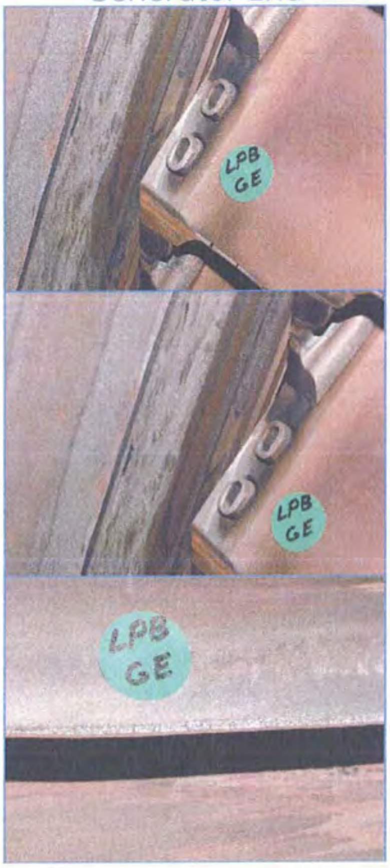
Turbine End

imagination at work

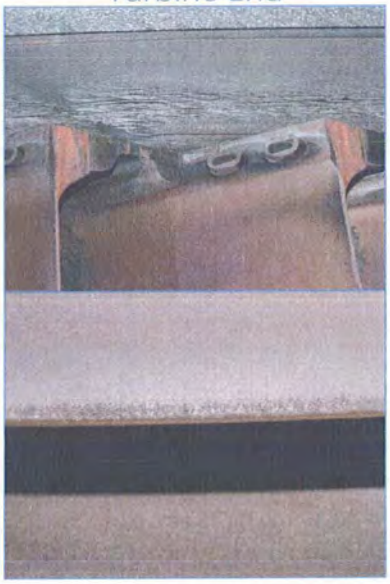
IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

LPB Photographs

Generator End



Turbine End

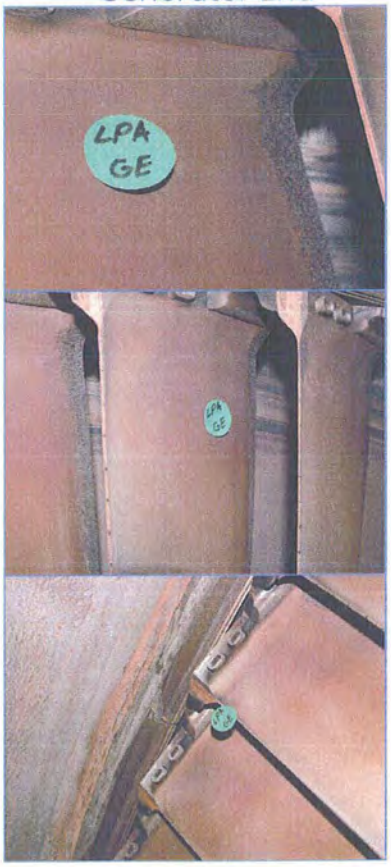


IP7019465

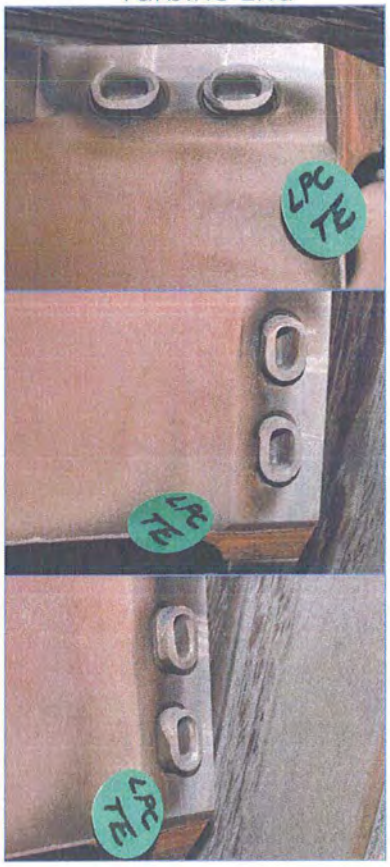
IPP, Unit 2 LSB Erosion (270T151)
April 7, 2008

LPC Photographs

Generator End



Turbine End



RECOMMENDATIONS

SHOULD BE DONE AT THE NEXT OUTAGE...

1. Buckets, LP; Assembly; LP A,B and C

Monitor LP L-0's per TIL-1521 and GEK46354 and replace on next major outage.

BUCKETS

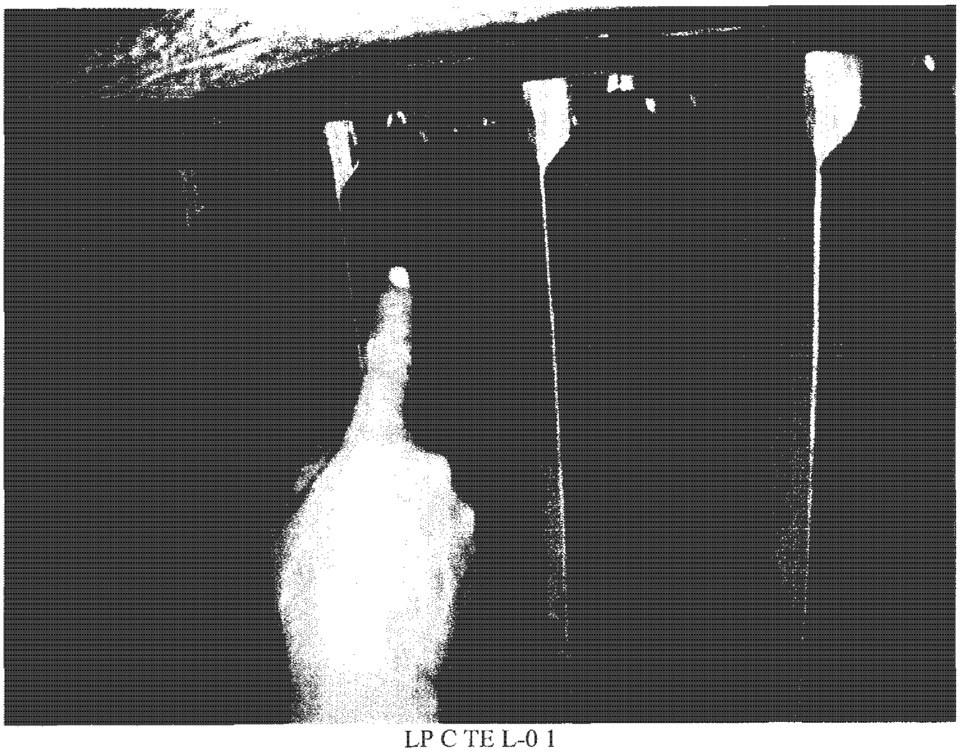
LP Buckets

Assembly; LP A,B and C

The L-0's on LP A, B, and C were visual and NDE examioned per TIL-1521 and GEK46354. As noted in past IPP QC records there is erosion on Inlet Side of all L-0 Buckets.

PRO comments are profile doesn't cause to much short term concern but should be replaced at next major outage.

Monitor LP L-0's per TIL-1521 and GEK46354 and replace on next major outage.



LP C TE L-0 1

APPENDIX

CUSTOMER [illegible]
STATION OWNERSHIP [illegible]
SERIAL NUMBER [illegible]
DATE [illegible]
STATION NAME [illegible]
UNIT NUMBER
REPORT # [illegible]
UNIT MAKE [illegible]

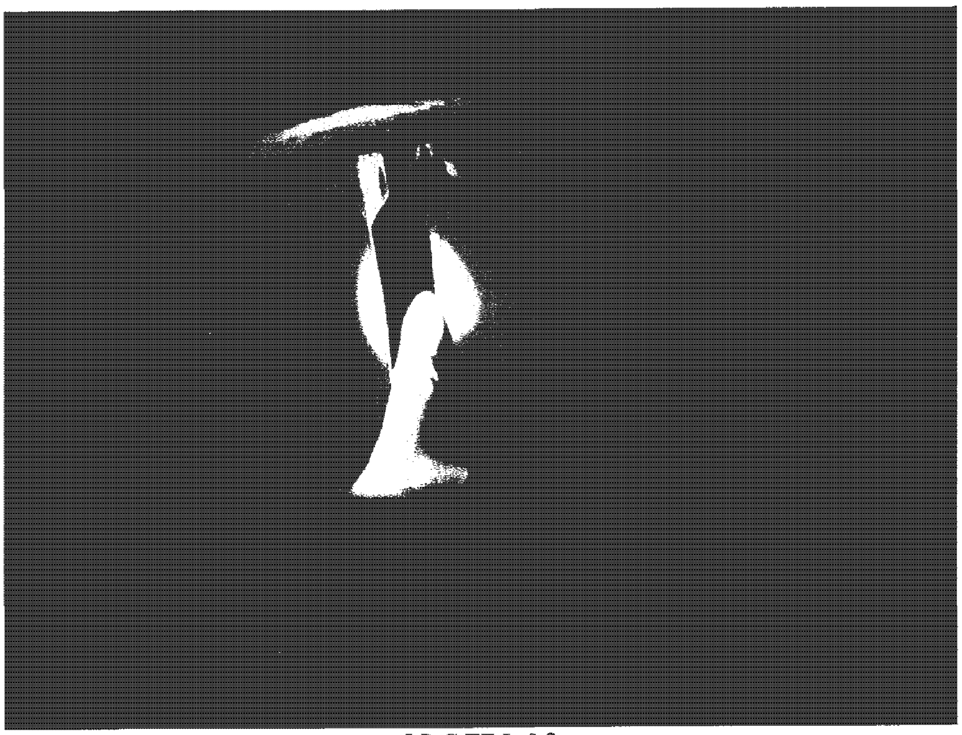
[illegible]	3	[illegible]	[illegible]
[illegible]			[illegible]
[illegible]			No defects found
[illegible]			
[illegible]	[illegible]		[illegible]
[illegible]			[illegible]
[illegible]			[illegible]
[illegible]	5		No defects found
[illegible]			

Scanned Document : NDT Report Page 8

BUCKETS

LP C TE L-0 3

BUCKETS



LP C TE L-0 2

Cost Analysis

IP7019472

Unit 1 LP Turbine Outage Repair Options Comparisons

	Repair/Insp new L-0 yr 10	New L-0 Hitachi 30"	LP Retrofit GE 34.5"	LP Retrofit Hitachi 33"
Costs (2010 Outage)	A	B	C	D
L-0 bucket replacement		$5,885,605		
upgraded packing & rings	$467,482	$467,482		
packing & ring installation	$54,000	$54,000		
diaphragm repair (15th & 16th)	$881,540	$881,540		
rotor bore US inspection	$150,000	$150,000		
packing alignment	$68,250	$68,250		
dovetail phased array insp	$61,000	$37,500		
L-0 cover removal, insp, replacement	$407,850			
Total - Maintenance Repairs	$2,090,122	$1,658,772		
LP Turbine retrofit (3 sections)			$40,673,000	$27,300,000
PV L-0 bucket replacement (yr 10)	$4,400,137			
Typical outage 30 days (28+2 startup)				
2010 planned outage length (days)	35	42	42	42
2010 outage extension (days)	0	7	7	7
Outage extension cost	$5,651,931	$7,560,000	$7,560,000	$7,560,000
Total Costs	$14,232,312	$16,763,149	$48,233,000	$34,860,000
Annual Savings				
NPHR improvement (Btu/kwh)	42	47	67	108
L-0 stage efficiency		$61,249		
Turbine seals & packing	$494,705	$494,705		
Improved steam path & L-0			$789,173	$1,272,099
Annual coal burn reduction (tons/yr)	12,760	14,340	20,355	32,811
Annual C02 reduction (tons/yr)	30,879	34,702	49,260	79,404
CO2 reduction savings ($/yr)	**$0**	**$0**	**$0**	**$0**
Total annual savings ($/yr)	$494,705	$555,954	$789,173	$1,272,099
Project Cost				
PV total period savings	$4,230,410	$4,754,175	$6,748,511	$10,878,196
NPV project	**-$10,001,902**	**-$12,008,974**	**-$41,484,489**	**-$23,981,804**
Ecomomic Factors				
Payback period (total costs)	28.77	30.15	61.12	27.40
Payback period (upgrade costs only)	1.05	11.52	51.54	21.46
Rate of return (total costs)	-13%	-14%	-22%	-13%
Rate of return (upgrade costs only)	101%	0%	-20%	-9%

Evaluation Criteria		
Outage year	2009	
Escalation (%)	3.00%	
Cost of Money (%)	6.04%	
Evaluation Period (yr)	10	
NPHR (Btu/kwh)	9500	
Net Capacity Factor (%)	90%	
Replacement Energy ($/MWh)	$50.00	
Fuel Cost ($/ton)	$38.77	38.77
Fuel Cost ($/mmBtu)	$1.66	1.66
CO2 tax ($/ton)	[redacted]	
FY 06-07 Production Values		
Total fuel cost ($1,000's)	231,047.0	
Net station generation (gwh)	14,686.0	
Total coal burned (ktons)	5,959.9	
Coal HHV (Btu/lb)	11,686	
NPHR (Btu/kwh)	9,491	
Net Capacity Factor (%)	93.1	

2/27/8

Legend

- Option A - New packing & rings, planned steam path repairs & inspections, inspect L-0 covers
- Option B - Same as Option A with replacement of L-0 buckets provided by Hitachi
- Option C - New (upgraded) LP turbine steam path provided by GE
- Option D - New (upgraded) LP turbine steam path provided by Hitachi 33" LSB new inner shell

IP7019473

Unit 1 LP Turbine Outage Repair Options Comparisons

	Repair/Insp new L-0 yr 10	New L-0 Hitachi 30"	LP Retrofit GE 34.5"	LP Retrofit Hitachi 33"
Costs (2010 Outage)	A	B	C	D
L-0 bucket replacement		$5,885,605		
upgraded packing & rings	$467,482	$467,482		
packing & ring installation	$54,000	$54,000		
diaphragm repair (15th & 16th)	$881,540	$881,540		
rotor bore US inspection	$150,000	$150,000		
packing alignment	$68,250	$68,250		
dovetail phased array insp	$61,000	$37,500		
L-0 cover removal, insp, replacement	$407,850			
Total - Maintenance Repairs	$2,090,122	$1,658,772		
LP Turbine retrofit (3 sections)			$40,673,000	$27,300,000
PV L-0 bucket replacement (yr 10)	$4,400,137			
Typical outage 30 days (28+2 startup)				
2010 planned outage length (days)	35	42	42	42
2010 outage extension (days)	0	7	7	7
Outage extension cost	$5,651,931	$7,560,000	$7,560,000	$7,560,000
Total Costs	$14,232,312	$16,763,149	$48,233,000	$34,860,000
Annual Savings				
NPHR improvement (Btu/kwh)	42	47	67	108
L-0 stage efficiency		$61,249		
Turbine seals & packing	$494,705	$494,705		
Improved steam path & L-0			$789,173	$1,272,099
Annual coal burn reduction (tons/yr)	12,760	14,340	20,355	32,811
Annual C02 reduction (tons/yr)	30,879	34,702	49,260	79,404
CO2 reduction savings ($/yr)	**$247,034**	**$277,619**	**$394,077**	**$635,229**
Total annual savings ($/yr)	$741,739	$833,573	$1,183,250	$1,907,328
Project Cost				
PV total period savings	$6,342,887	$7,128,196	$10,118,414	$16,310,280
NPV project	**-$7,889,425**	**-$9,634,953**	**-$38,114,586**	**-$18,549,720**
Ecomomic Factors				
Payback period (total costs)	19.19	20.11	40.76	18.28
Payback period (upgrade costs only)	0.70	7.69	34.37	14.31
Rate of return (total costs)	-8%	-8%	-17%	-7%
Rate of return (upgrade costs only)	149%	8%	-15%	-3%

Evaluation Criteria		
Outage year	2009	
Escalation (%)	3.00%	
Cost of Money (%)	6.04%	
Evaluation Period (yr)	10	
NPHR (Btu/kwh)	9500	
Net Capacity Factor (%)	90%	
Replacement Energy ($/MWh)	$50.00	
Fuel Cost ($/ton)	$38.77	38.77
Fuel Cost ($/mmBtu)	$1.66	1.66
CO2 tax ($/ton)	[redacted]	
FY 06-07 Production Values		
Total fuel cost ($1,000's)	231,047.0	
Net station generation (gwh)	14,686.0	
Total coal burned (ktons)	5,959.9	
Coal HHV (Btu/lb)	11,686	
NPHR (Btu/kwh)	9,491	
Net Capacity Factor (%)	93.1	

Legend

- Option A - New packing & rings, planned steam path repairs & inspections, inspect L-0 covers
- Option B - Same as Option A with replacement of L-0 buckets provided by Hitachi
- Option C - New (upgraded) LP turbine steam path provided by GE
- Option D - New (upgraded) LP turbine steam path provided by Hitachi 33" LSB new inner shell

IP7019474

Unit 1 LP Turbine Outage Repair Options Comparisons

	Repair/Insp new L-0 yr 10	New L-0 Hitachi 30"	LP Retrofit GE 34.5"	LP Retrofit Hitachi 33"
Costs (2010 Outage)	A	B	C	D
L-0 bucket replacement		$5,885,605		
upgraded packing & rings	$467,482	$467,482		
packing & ring installation	$54,000	$54,000		
diaphragm repair (15th & 16th)	$881,540	$881,540		
rotor bore US inspection	$150,000	$150,000		
packing alignment	$68,250	$68,250		
dovetail phased array insp	$61,000	$37,500		
L-0 cover removal, insp, replacement	$407,850			
Total - Maintenance Repairs	$2,090,122	$1,658,772		
LP Turbine retrofit (3 sections)			$40,673,000	$27,300,000
PV L-0 bucket replacement (yr 10)	$4,400,137			
Typical outage 30 days (28+2 startup)				
2010 planned outage length (days)	35	42	42	42
2010 outage extension (days)	0	7	7	7
Outage extension cost	$5,651,931	$7,560,000	$7,560,000	$7,560,000
Total Costs	$14,232,312	$16,763,149	$48,233,000	$34,860,000
Annual Savings				
NPHR improvement (Btu/kwh)	42	47	67	108
L-0 stage efficiency		$61,249		
Turbine seals & packing	$494,705	$494,705		
Improved steam path & L-0			$789,173	$1,272,099
Annual coal burn reduction (tons/yr)	12,760	14,340	20,355	32,811
Annual C02 reduction (tons/yr)	30,879	34,702	49,260	79,404
CO2 reduction savings ($/yr)	**$617,584**	**$694,047**	**$985,194**	**$1,588,073**
Total annual savings ($/yr)	$1,112,289	$1,250,001	$1,774,366	$2,860,172
Project Cost				
PV total period savings	$9,511,602	$10,689,229	$15,173,270	$24,458,405
NPV project	**-$4,720,710**	**-$6,073,920**	**-$33,059,730**	**-$10,401,595**
Ecomomic Factors				
Payback period (total costs)	12.80	13.41	27.18	12.19
Payback period (upgrade costs only)	0.47	5.13	22.92	9.54
Rate of return (total costs)	-1%	-2%	-12%	-1%
Rate of return (upgrade costs only)	223%	18%	-10%	4%

Legend

Option A - New packing & rings, planned steam path repairs & inspections, inspect L-0 covers
Option B - Same as Option A with replacement of L-0 buckets provided by Hitachi
Option C - New (upgraded) LP turbine steam path provided by GE
Option D - New (upgraded) LP turbine steam path provided by Hitachi 33" LSB new inner shell

Evaluation Criteria		
Outage year	2009	
Escalation (%)	3.00%	
Cost of Money (%)	6.04%	
Evaluation Period (yr)	10	
NPHR (Btu/kwh)	9500	
Net Capacity Factor (%)	90%	
Replacement Energy ($/MWh)	$50.00	
Fuel Cost ($/ton)	$38.77	38.77
Fuel Cost ($/mmBtu)	$1.66	1.66
CO2 tax ($/ton)	[redacted]	

FY 06-07 Production Values	
Total fuel cost ($1,000's)	231,047.0
Net station generation (gwh)	14,686.0
Total coal burned (ktons)	5,959.9
Coal HHV (Btu/lb)	11,686
NPHR (Btu/kwh)	9,491
Net Capacity Factor (%)	93.1

IP7019475

Unit 1 LP Turbine Outage Repair Options Comparisons

	Repair/Insp new L-0 yr 10	New L-0 Hitachi 30"	LP Retrofit GE 34.5"	LP Retrofit Hitachi 33"
Costs (2010 Outage)	A	B	C	D
L-0 bucket replacement		$5,885,605		
upgraded packing & rings	$467,482	$467,482		
packing & ring installation	$54,000	$54,000		
diaphragm repair (15th & 16th)	$881,540	$881,540		
rotor bore US inspection	$150,000	$150,000		
packing alignment	$68,250	$68,250		
dovetail phased array insp	$61,000	$37,500		
L-0 cover removal, insp, replacement	$407,850			
Total - Maintenance Repairs	$2,090,122	$1,658,772		
LP Turbine retrofit (3 sections)			$40,673,000	$27,300,000
PV L-0 bucket replacement (yr 10)	$4,400,137			
Typical outage 30 days (28+2 startup)				
2010 planned outage length (days)	35	42	42	42
2010 outage extension (days)	0	7	7	7
Outage extension cost	$5,651,931	$7,560,000	$7,560,000	$7,560,000
Total Costs	$14,232,312	$16,763,149	$48,233,000	$34,860,000
Annual Savings				
NPHR improvement (Btu/kwh)	42	47	67	108
L-0 stage efficiency		$61,249		
Turbine seals & packing	$494,705	$494,705		
Improved steam path & L-0			$789,173	$1,272,099
Annual coal burn reduction (tons/yr)	12,760	14,340	20,355	32,811
Annual C02 reduction (tons/yr)	30,879	34,702	49,260	79,404
CO2 reduction savings ($/yr)	**$1,543,960**	**$1,735,117**	**$2,462,984**	**$3,970,183**
Total annual savings ($/yr)	$2,038,665	$2,291,072	$3,252,157	$5,242,282
Project Cost				
PV total period savings	$17,433,390	$19,591,810	$27,810,409	$44,828,718
NPV project	**$3,201,079**	**$2,828,661**	**-$20,422,591**	**$9,968,718**
Ecomomic Factors				
Payback period (total costs)	6.98	7.32	14.83	6.65
Payback period (upgrade costs only)	0.26	2.80	12.51	5.21
Rate of return (total costs)	10%	9%	-4%	11%
Rate of return (upgrade costs only)	406%	38%	-1%	17%

Evaluation Criteria		
Outage year	2009	
Escalation (%)	3.00%	
Cost of Money (%)	6.04%	
Evaluation Period (yr)	10	
NPHR (Btu/kwh)	9500	
Net Capacity Factor (%)	90%	
Replacement Energy ($/MWh)	$50.00	
Fuel Cost ($/ton)	$38.77	38.77
Fuel Cost ($/mmBtu)	$1.66	1.66
CO2 tax ($/ton)	[redacted]	
FY 06-07 Production Values		
Total fuel cost ($1,000's)	231,047.0	
Net station generation (gwh)	14,686.0	
Total coal burned (ktons)	5,959.9	
Coal HHV (Btu/lb)	11,686	
NPHR (Btu/kwh)	9,491	
Net Capacity Factor (%)	93.1	

Legend

Option A - New packing & rings, planned steam path repairs & inspections, inspect L-0 covers

Option B - Same as Option A with replacement of L-0 buckets provided by Hitachi

Option C - New (upgraded) LP turbine steam path provided by GE

Option D - New (upgraded) LP turbine steam path provided by Hitachi 33" LSB new inner shell

Unit 1 LP Turbine Outage Repair Options Comparisons

		New L-0	GE	Hitachi
Costs	A	B	C	D
upgraded packing & rings	$467,482	$467,482		
packing & ring installation	$54,000	$54,000		
L-0 bucket replacement		$5,885,605		
LP Turbine uprate (3 sections)			$40,673,000	$27,300,000
diaphragm repair (15th & 16th)	$881,540	$881,540		
rotor bore US inspection	$150,000	$150,000		
packing alignment	$68,250	$68,250		
dovetail phased array insp	$61,000	$37,500		
L-0 cover removal, insp, replacement	$407,850			
Outage extension days	$7,560,000	$15,120,000	$22,680,000	$22,680,000
Total Costs	$9,650,122	$22,664,377	$63,353,000	$49,980,000
Savings				
Annual fuel cost savings from improved LP efficiency	$494,705	$555,954	$1,825,698	$2,084,829
Annual coal burn reduction (tons/yr)	12,760	14,340	47,090	53,774
Annual C02 reduction (tons/yr)	30,879	34,702	113,959	130,134
CO2 reduction savings ($/yr)	$0	$0	$0	$0
Total annual savings ($/yr)	$494,705	$555,954	$1,825,698	$2,084,829
Economic Factors				
PV total period savings	$4,230,410	$4,754,175	$15,612,226	$17,828,155
NPV project	-$5,419,712	-$17,910,202	-$47,740,774	-$32,151,845
Payback period (total costs)	19.51	40.77	34.70	23.97
Payback period (upgrade costs only)	1.05	11.52	22.28	13.09
Rate of return (total costs)	-8%	-17%	-15%	-11%
Rate of return (upgrade costs only)	101%	0%	-10%	-2%

Evaluation Criteria		
Outage year	2009	
Escalation (%)	3.00%	
Cost of Money (%)	6.04%	
Evaluation Period (yr)	10	
NPHR (Btu/kwh)	9500	
Net Capacity Factor (%)	90%	
Replacement Energy ($/MWh)	$50.00	
Fuel Cost ($/ton)	$38.77	38.77
Fuel Cost ($/mmBtu)	$1.66	1.66
CO2 tax ($/ton)	$0.00	

FY 06-07 Production Values	
Total fuel cost ($1,000's)	231,047.0
Net station generation (gwh)	14,686.0
Total coal burned (ktons)	5,959.9
Coal HHV (Btu/lb)	11,686
NPHR (Btu/kwh)	9,491
Net Capacity Factor (%)	93.1

231047

5960

Option A - New packing & rings, planned steam path repairs & inspections, inspect L-0 covers
Option B - Same as Option A with replacement of L-0 buckets provided by Hitachi
Option C - New (upgraded) LP turbine steam path provided by GE
Option D - New (upgraded) LP turbine steam path provided by Hitachi 33" LSB new inner shell

IP7019477

LP Turbine Maintenance Option - A

Repair Scope

- L-0 bucket tip inspection
- L-0, L-1, L-2 bucket root phased array US inspection
- 15th & 16th diaphragm major repairs (100% 15th, 50% 16th) 15 - 17 days
- Replace all packing and seals with upgraded product
- Rotor bore US inspection
- Outage schedule - 35 days, U2 2010, U1 2011 (1 week ext based on 1999 & 2000 outages)

Savings Calculation:

Savings based on 1.4 MW increased output per LP shell (4.2 MW total LP output) listed on page 3 of Turbo Parts LLC 8/24/07 quote T07-1577

4.20	MW gross change in full load	
3.98	MW net	
0.4421%	change in net power	
42	Btu/kwh change in NPHR	
$494,705	annual savings	
$7,560,000	Additional costs - outage extension	7 days
$4,230,410	NPV of annual savings	

year	FV escalation	
	-$9,650,122	-$521,482
1	$509,546	$509,546
2	$524,833	$524,833
3	$540,578	$540,578
4	$556,795	$556,795
5	$573,499	$573,499
6	$590,704	$590,704
7	$608,425	$608,425
8	$626,678	$626,678
9	$645,478	$645,478
10	$664,842	$664,842

IP7019478

LP Turbine Maintenance Option - B

Repair Scope

- New L-0 buckets - Hitachi supplied (GE $1.1m higher)
- L-1, L-2 bucket root phased array US inspection
- 15th & 16th diaphragm major repairs
- Replace all packing and seals with upgraded product
- Rotor bore US inspection
- Outage extension 14 days - 42 days total in 2010 (L-0 replacement 33-35 days)

Savings Calculation:

Savings based on 1.4 MW increased output per LP shell (4.2 MW total LP output) listed on page 3 of Turbo Parts LLC 8/24/07 quote T07-1577 from new packings and spill strips
& 0.52 MW increase for improved design L-0 buckets pg 3 10/18/07 MDA quote 70458A (0.8% stg efficiency improvement)

4.72	MW gross change in full load	
4.47	MW net	
0.4968%	change in net power	
47	Btu/kwh change in NPHR	
$555,954	annual savings	
$15,120,000	Additional costs - outage extension	14 days
$4,754,175	NPV of annual savings	

year	FV escalation	
	-$22,664,377	-$6,407,087
1	$572,633	$572,633
2	$589,812	$589,812
3	$607,506	$607,506
4	$625,732	$625,732
5	$644,504	$644,504
6	$663,839	$663,839
7	$683,754	$683,754
8	$704,266	$704,266
9	$725,394	$725,394
10	$747,156	$747,156

LP Turbine Maintenance Option - C

Repair Scope

New steampath (diaphragms & rotors & inner shells) all 3 LP turbines provided by GE
Outage extension 14 days - 42 days total in 2010 (for comparison only) actual soonest install 2011

Savings Calculation:

Savings based on 15.5 MW output increase (maximum quoted by GE) stated on pg 6 of GE proposal 1-16P6455 rev. 0 issued 11/13/07

15.50	MW gross change in full load	
14.68	MW net	
1.6316%	change in net power	
155	Btu/kwh change in NPHR	
$1,825,698	annual savings	
$22,680,000	Additional costs - outage extension	21 days
$15,612,226	NPV of annual savings	

year	FV escalation	
	-$63,353,000	-$40,673,000
1	$1,880,469	$1,880,469
2	$1,936,883	$1,936,883
3	$1,994,989	$1,994,989
4	$2,054,839	$2,054,839
5	$2,116,484	$2,116,484
6	$2,179,979	$2,179,979
7	$2,245,378	$2,245,378
8	$2,312,739	$2,312,739
9	$2,382,122	$2,382,122
10	$2,453,585	$2,453,585

LP Turbine Maintenance Option - D

Repair Scope

New steampath (diaphragms & rotors) all 3 LP turbines provided by Toshiba ($8.35m x 3 = $25.05m for 30" LSB, $9.1 x 3 = $27.3m for 33" LSB

Outage extension 21 days - 49 days total in 2010 for camparison only (38-42 days for retro work)

Savings Calculation:

Savings based on 17.7 MW output increase quoted in 2/6/8 meeting with MDA for 33" LSB

17.70	MW gross change in full load	
16.77	MW net	
1.8632%	change in net power	
177	Btu/kwh change in NPHR	
$2,084,829	annual savings	
$22,680,000	Additional costs - outage extension	21 days
$17,828,155	NPV of annual savings	

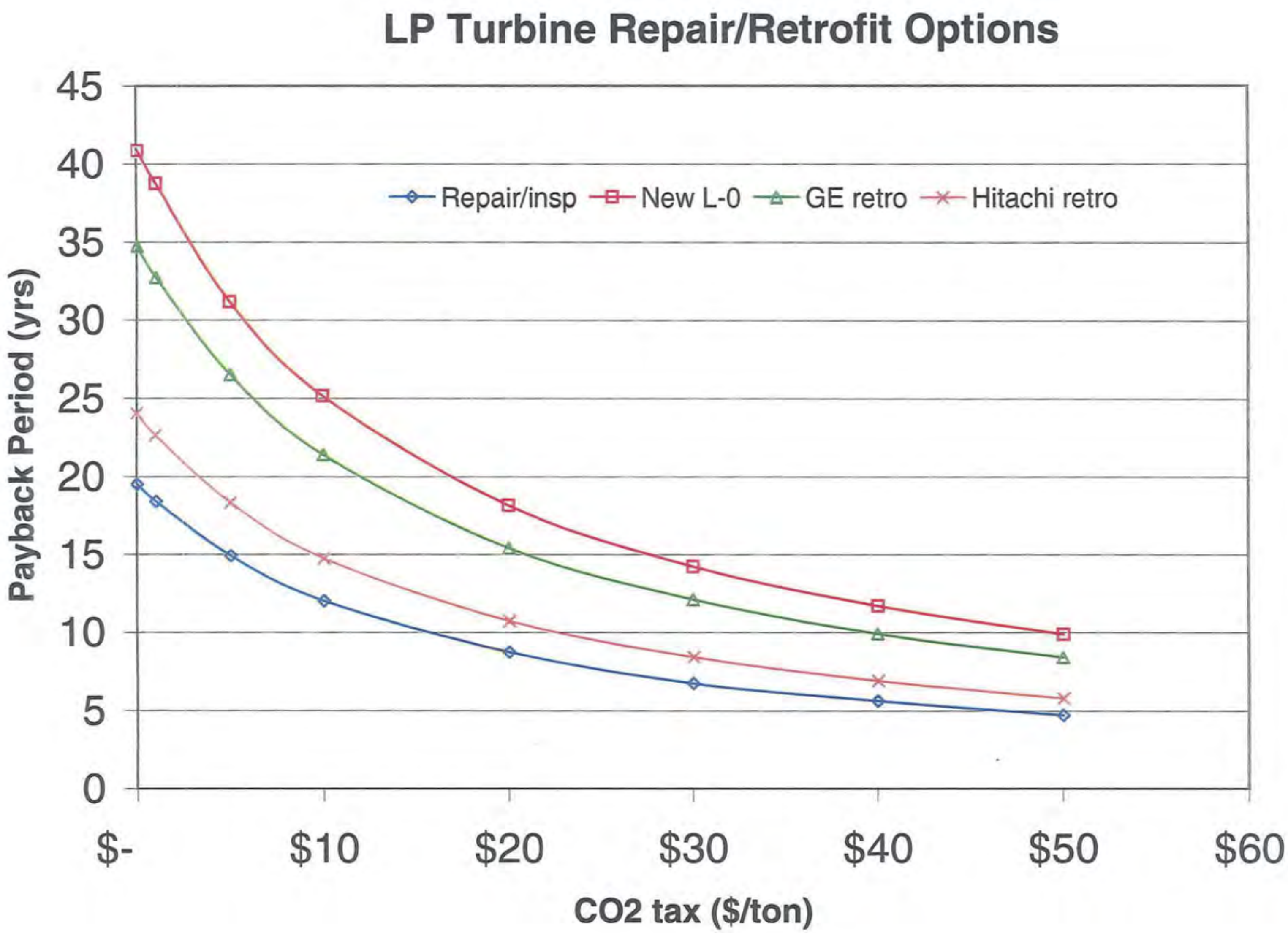
year	FV escalation	
	-$49,980,000	-$27,300,000
1	$2,147,374	$2,147,374
2	$2,211,795	$2,211,795
3	$2,278,149	$2,278,149
4	$2,346,494	$2,346,494
5	$2,416,888	$2,416,888
6	$2,489,395	$2,489,395
7	$2,564,077	$2,564,077
8	$2,640,999	$2,640,999
9	$2,720,229	$2,720,229
10	$2,801,836	$2,801,836

Unit 1 LP Turbine Outage Repair Options Comparisons

		New L-0	GE	Hitachi
Costs	A	B	C	D
upgraded packing & rings	$467,482	$467,482		
packing & ring installation	$54,000	$54,000		
L-0 bucket replacement		$5,885,605		
LP Turbine uprate (3 sections)			$40,673,000	$27,300,000
diaphragm repair (15th & 16th)	$881,540	$881,540		
rotor bore US inspection	$150,000	$150,000		
packing alignment	$68,250	$68,250		
dovetail phased array insp	$61,000	$37,500		
L-0 cover removal, insp, replacement	$407,850			
Outage extension	$7,560,000	$15,120,000	$22,680,000	$22,680,000
Total Costs	$9,650,122	$22,664,377	$63,353,000	$49,980,000
Savings				
Annual fuel cost savings from improved LP efficiency	$494,705	$555,954	$1,825,698	$2,084,829
Annual coal burn reduction (tons/yr)	12,760	14,340	47,090	53,774
Annual C02 reduction (tons/yr)	30,879	34,702	113,959	130,134
CO2 reduction savings ($/yr)	$0	$0	$0	$0
Total annual savings ($/yr)	$494,705	$555,954	$1,825,698	$2,084,829
Economic Factors				
PV total period savings	$4,230,410	$4,754,175	$15,612,226	$17,828,155
NPV project	-$5,419,712	-$17,910,202	-$47,740,774	-$32,151,845
Payback period (total costs)	19.51	40.77	34.70	23.97
Payback period (upgrade costs only)	1.05	11.52	22.28	13.09
Rate of return (total costs)	-8%	-17%	-15%	-11%
Rate of return (upgrade costs only)	101%	0%	-10%	-2%

Evaluation Criteria		
Outage year	2009	
Escalation (%)	3.00%	
Cost of Money (%)	6.04%	
Evaluation Period (yr)	10	
NPHR (Btu/kwh)	9500	
Net Capacity Factor (%)	90%	
Replacement Energy ($/MWh)	$50.00	
Fuel Cost ($/ton)	$38.77	38.77
Fuel Cost ($/mmBtu)	$1.66	1.66
CO2 tax ($/ton)	$0.00	
FY 06-07 Production Values		
Total fuel cost ($1,000's)	231,047.0	
Net station generation (gwh)	14,686.0	
Total coal burned (ktons)	5,959.9	
Coal HHV (Btu/lb)	11,686	
NPHR (Btu/kwh)	9,491	
Net Capacity Factor (%)	93.1	

Option A - New packing & rings, planned steam path repairs & inspections, inspect L-0 covers
Option B - Same as Option A with replacement of L-0 buckets provided by Hitachi
Option C - New (upgraded) LP turbine steam path provided by GE
Option D - New (upgraded) LP turbine steam path provided by Hitachi 33" LSB new inner shell


LP Turbine Repair/Retrofit Options
Repair/insp
New L-0
GE retro
Hitachi retro
Payback Period (yrs)
45
40
35
30
25
20
15
10
5
0
$-
$10
$20
$30
$40
$50
$60
CO2 tax ($/ton)

IP7019483

MDA Insp.

MECHANICAL DYNAMICS and ANALYSIS, LTD

MECHANICAL DYNAMICS & ANALYSIS, LTD.
29 BRITISH AMERICAN BLVD., LATHAM, NEW YORK 12110
PHONE: (518) 399-3616 FAX: (518) 399-3929
www.MDAturbines.com

May 27, 2008

Mr. David Spence
Intermountain Power
850 West Brush Wellman Road
Delta, UT 84624

Tel: 435-864-6449
E-mail: dave-s@ipsc.com

SUBJECT: Inspection of Intermountain 2 Last Stage Buckets

Dear David:

In April, MD&A inspected the last stage buckets of Intermountain #2 in the hoods to provide Intermountain Power with a second opinion concerning the need to replace the buckets during a planned outage in 2010. Intermountain #2 is a GE S2 turbine with 30" last stage buckets and steam conditions of 2400#/1000°F/1000°F that went into service in 1987. The turbine was originally rated at 820 MW but you reported that the HP sections of both Intermountain units have been replaced with Alstom upgrades so the output is now higher.

INSPECTION

The 6 rows of last stage buckets were inspected by crawling through the manways into the exhaust hoods. The NDE of the last stage buckets had not been done.

The last stage buckets had a moderate amount of erosion on the leading edge near the tip, with no significant notches. It was reported that the erosion found at the last outage in 2000 was ground to remove the rough material. It should be noted that these 30" last stage buckets are GE's self-shielded design with no Stellite erosion shield.

The side entry covers had moderate erosion on the leading edge and moderate to heavy erosion on the swelled tenons on the discharge side. The worst swelled tenon erosion was on 20TB where the tenons were undercut at the root with the 3/32" thickness at the top reduced to .035" at the bottom.

The erosion on the trailing edge from the tie wire in is only slight, with no notches observed in the trailing edges.

Details of the last stage bucket inspection are shown in Table 1.

08-66058 line 1 Closed 6/10/8 email to Kathy Barnes

RECOMMENDATIONS/CONCLUSIONS

1. The last stage bucket erosion is not sufficient to require replacement if the buckets had erosion shields.

   - The level of erosion on the admission edge near the tip is less than that seen on shielded buckets which have continued to operate successfully. There were no significant notches observed in the leading edge which would produce stress concentrations and increase the possibility of crack initiation. Please note that cracks that do initiate in erosion shields on 30" continuously coupled buckets tend to stop in the ductile Inconel welds that attach the shields.

2. Replacing these unshielded L-0 buckets with shielded buckets would minimize the chance of a bucket failure.

   - Last stage bucket failures in the last few years seem to indicate that unshielded last stage buckets, like the buckets on the Intermountain units, may have a shorter life than shielded buckets. MD&A is aware of 4 tip failures of unshielded 30" last stage buckets in 2004 and 2005 but unaware of similar failures of the older shielded 30" continuously coupled buckets. Unlike the buckets with Stellite erosion shields, the unshielded buckets do not have a ductile Inconel layer to stop cracks that initiate on the leading edge. In addition, it appears that the hardness level of the buckets may have been increased and ductility decreased when the EBW shields were eliminated. The failures all occurred after cracks initiated on the leading edge near the tip and propagated across the blade until the tip broke off, causing a forced outage. There is suspicion that incorrect installation of replacement covers caused 2 of the 30" failures but it is likely that the negative aspects of the unshielded design contributed to the failures. Please note that MD&A inspected one of the 30" rows that had a bucket failure and found the leading edge erosion to be less than that of many 30" and 33 ½" L-0 rows previously seen that are operating reliably.

root problems
New bucket
covers too tight
inst by Alstom
MD&A did failure
Analysis

3. The last stage covers should be replaced if the buckets are not replaced.

   - The erosion of up to nearly 2/3 of the thickness of the discharge side tenons is severe enough to require replacement. Please note that special attention should be given to the swelling of the discharge tenons because incorrect swelling of the discharge tenons is considered the likely cause of two of the 30" L-0 failures. It appeared that extending the swelling too far toward the bucket restricted the ability of the bucket to untwist during service and increased the stress at the base of the trapezoidal section at the tip of the vane. The increased stress plus erosion notches in the leading edges combined to initiate cracks which resulted in tip failures on the unshielded 30" buckets. This special attention to the swelling process should also be applied to a new bucket installation if the new buckets have the same side entry cover design as the current last stage buckets.

4. Don't run with high back pressure.

   - Running with high back pressure increases the vibratory stresses in the buckets, especially during low load operation. Although the continuous coupling of the last stage buckets reduces the response to the stimulus from high back pressure, the stress levels are still higher than those at normal operating conditions.

5. Remove the L-0 spill strip holder for cleaning if the opening is blocked with deposits.

   - The last stage bolted spill strip holder has a gap to the diaphragm that allows moisture on the outer sidewall of the diaphragm to go straight to the condenser without passing through the last stage buckets. If that passage is blocked, then the water must go through the last stage buckets, increasing the erosion on the admission vane tip. During the next LP inspection, a light can be placed on the inside of the passage and if it can be seen from the outside, then no action is required. If the light cannot be seen, then deposits have accumulated in the gap and the spill strip holders should be removed to allow the two surfaces to be blast cleaned. Bolts may break or require drilling, so you may want to have some on hand.

6. The discharge side L-0 bucket erosion is acceptable as is.

   - The erosion on the convex sides of some blades has not progressed to the point that there are notches in the trailing edge. If there are notches at future outages, then the trailing edge should be ground back to remove the notches.

Photographs of the Intermountain 2 last stage buckets are included as Figures 1-26. In addition, photographs of 2 of the 30" unshielded bucket failures are included as Figures 27-30.

The opportunity to serve Intermountain Power is appreciated. Please feel free to contact me if you have any questions.

Sincerely,

Jeffrey R Newton

Jeffrey R. Newton
Consulting engineer

Attachments

CC: D.E. Hatcher
B.R. Woody
P.D. Lamovec
P.L. Wilhelm
B. Allen
L. Molina

S:\JRN\2008\08-003 - Intermountain Power #2.doc

IP7019487

MECHANICAL DYNAMICS and ANALYSIS, LTD

TABLE 1

INTERMOUNTAIN POWER - 30" LAST STAGE BUCKETS – APRIL 2008	
TA	-Trailing edge erosion heaviest of the 6 ends, with erosion up to near the tie wire on many, but no notches in trailing edge. -Discharge side tenon erosion similar to 20GA and much less than 20TB, with minimum wall thickness ≈.060". -Erosion on admission side of cover is moderate and similar to other rows. -Admission edge has erosion back from leading edge as on other turbine end rows, but erosion less than TB and TC, with erosion back 1/8".
GA	-Trailing edge erosion similar to "B", with heavy erosion on some and none on others, but even on buckets with heavy erosion, the erosion has not produced notches in the trailing edge. -Discharge side tenon erosion <"B", with thickness in eroded areas at base on inside ≈.065"-.070". -Admission side of cover has moderate erosion similar to "B" and "C". -Admission vane tip has slight erosion back from leading edge (up to 1/8"), with the heaviest erosion only going down a few inches (<TB or TC). No significant notches in leading edge.
TB	-Trailing edge erosion approximately the same as GB or slightly worse, but there are no erosion grooves that result in notches in the trailing edge. -Swelled tenons as bad or slightly worse than GB. -Swelled tenon sides about 3/32" thick at top. Eroded to .035" thick on leading side on inside (2/3 gone). -Leading edge erosion similar to TC, with erosion on convex side back 1/8"-3/16" from leading edge. Heavier erosion down 3"-4" from tip.
GB	-Trailing edge erosion worse than "C", but still no erosion grooves extend to trailing edge. -Discharge side tenons have erosion similar to "C" on the top which is worse on the trailing tenon. There is also up to 1/16" of erosion on the base of the tenons with the most on the front tenon on the inside. -Leading side of cover eroded moderately and similar to "C". -Leading edge of vane appears to have less erosion than TC and about the same as GC, without the step seen on TC. Heaviest erosion only goes down a few inches.
TC	-Trailing edge has more erosion than GC, with the buckets that are apparently more downstream having some erosion grooves on convex side inside tie wire, but no notches in trailing edge. -Discharge side tenons and admission side of cover similar to 20GC. -Admission edges of vanes have more erosion than 20GC, with erosion back 1/16"-3/16" from leading edge but no significant notches in leading edge. Heavier erosion down 3"-4".
GC	-Virtually no erosion on trailing edge. -Some erosion on discharge side tenons, with erosion completely through on a few trailing tenons. -Moderate erosion on leading edges of covers. -Moderate erosion on leading edges of vanes near the tip down 2"-3" from the bottom of the trapezoid.

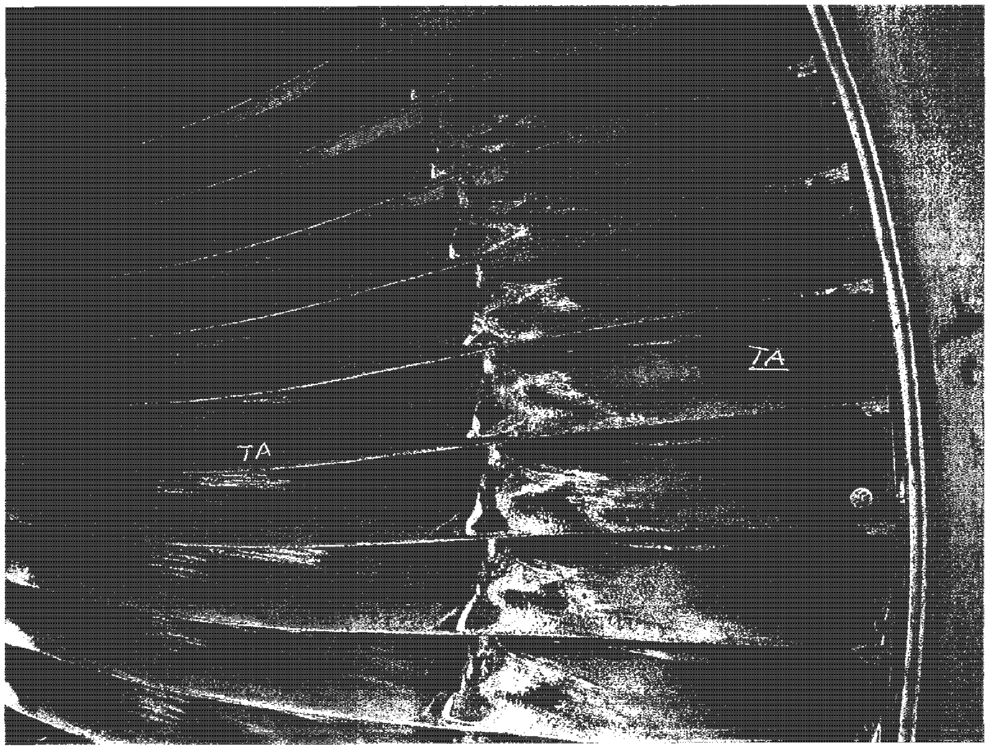


Figure 1-TA Last Stage Buckets

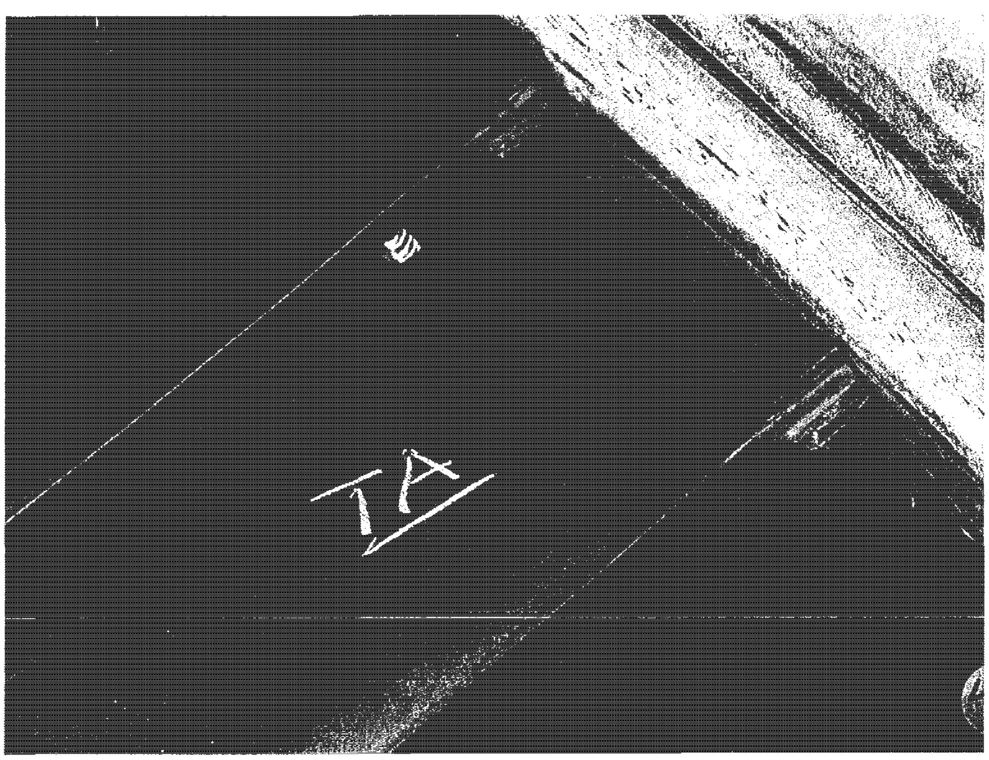


Figure 2-TA Last Stage Bucket Tips with Side Entry Covers

Figure 3-TA Last Stage Bucket with Erosion on Leading Edge

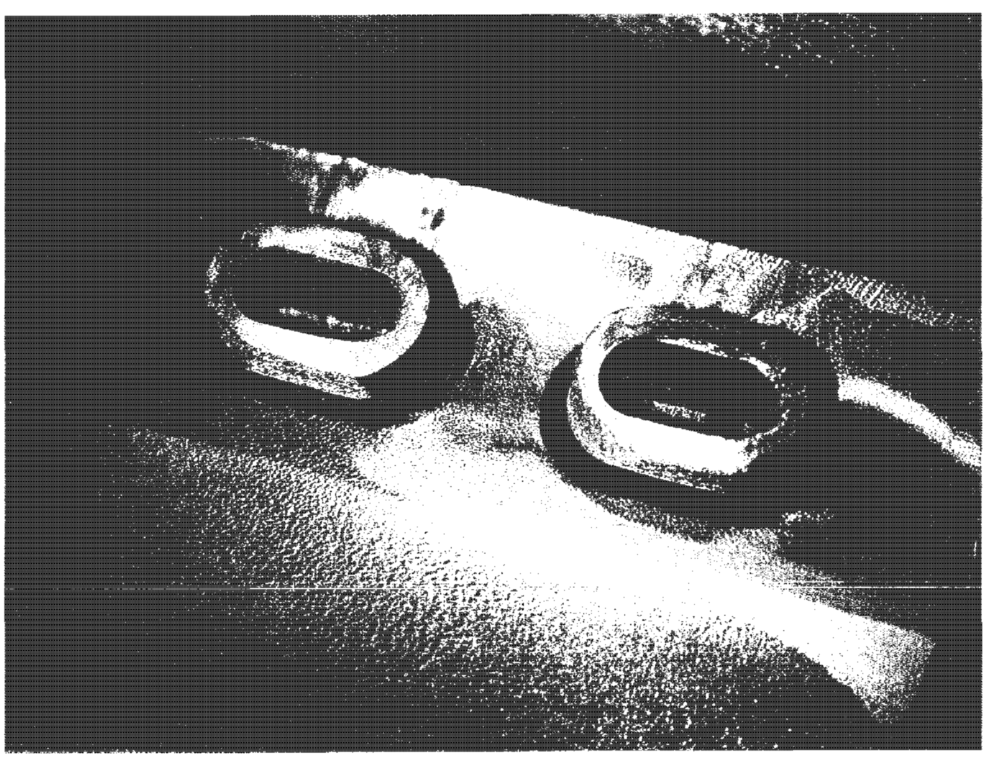


Figure 4-TA Last Stage Swelled Tenons

IP7019490

Figure 5-TA Last Stage Bucket with Erosion on Discharge Edge

Figure 6-GA Last Stage Buckets

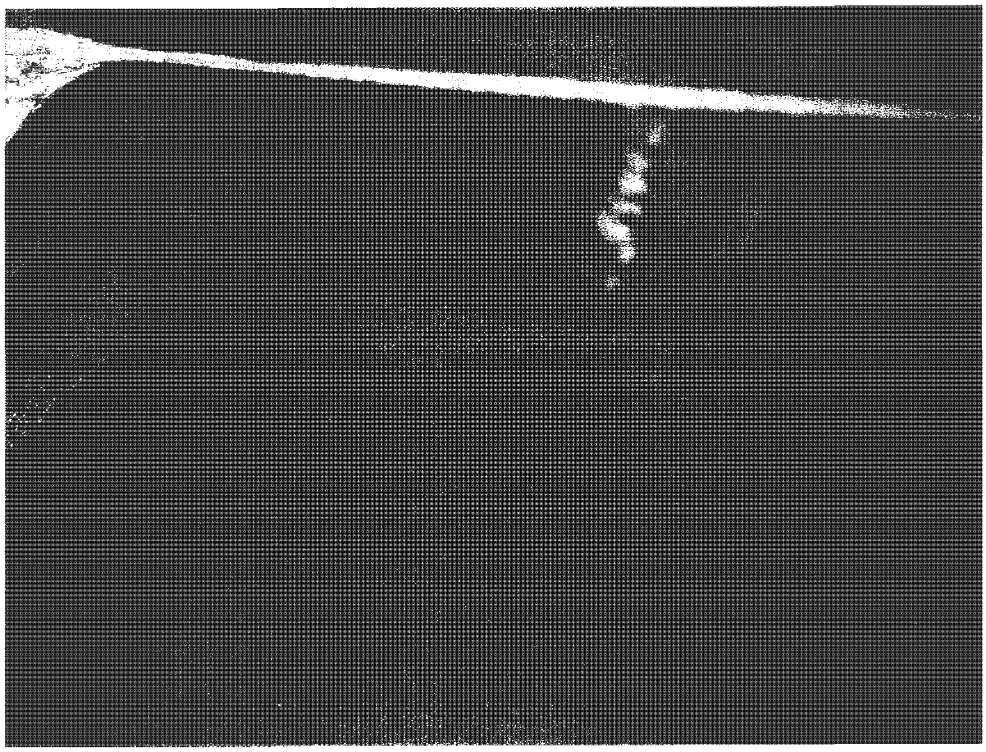


Figure 7-GA Last Stage Bucket with Erosion on Leading Edge of Vane and Cover

Figure 8-GA Last Stage Swelled Tenons with Erosion at Base

Figure 9-GA Last Stage Bucket with Erosion on Discharge Edge

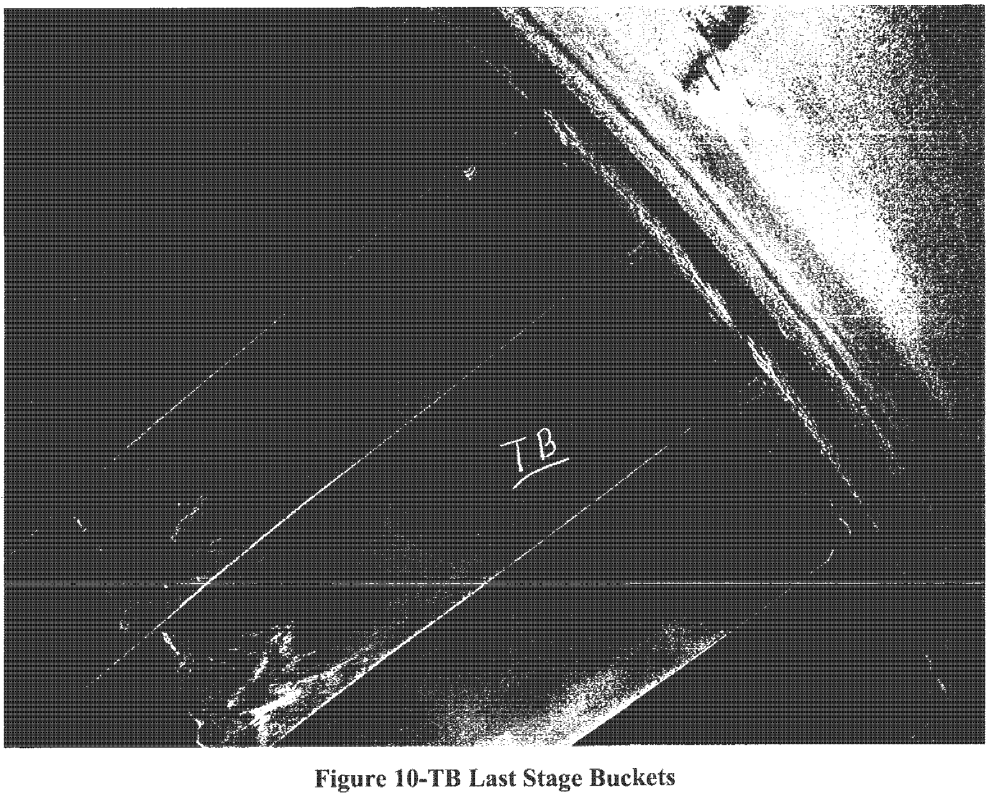


Figure 10-TB Last Stage Buckets

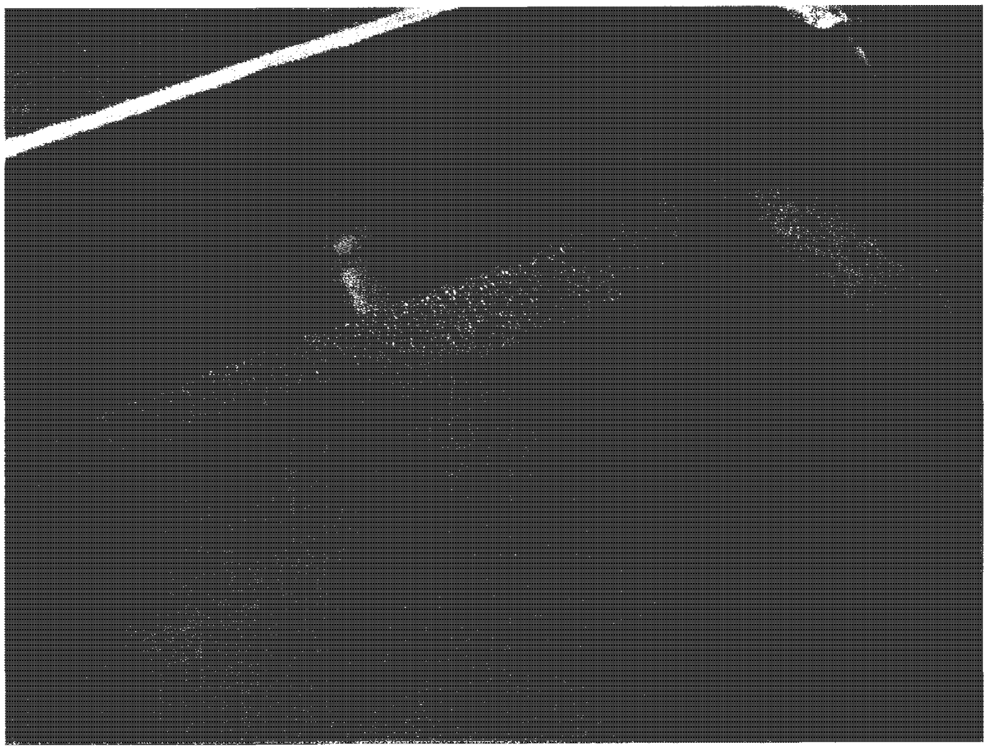


Figure 11-TB Last Stage Bucket with Erosion on Leading Edge

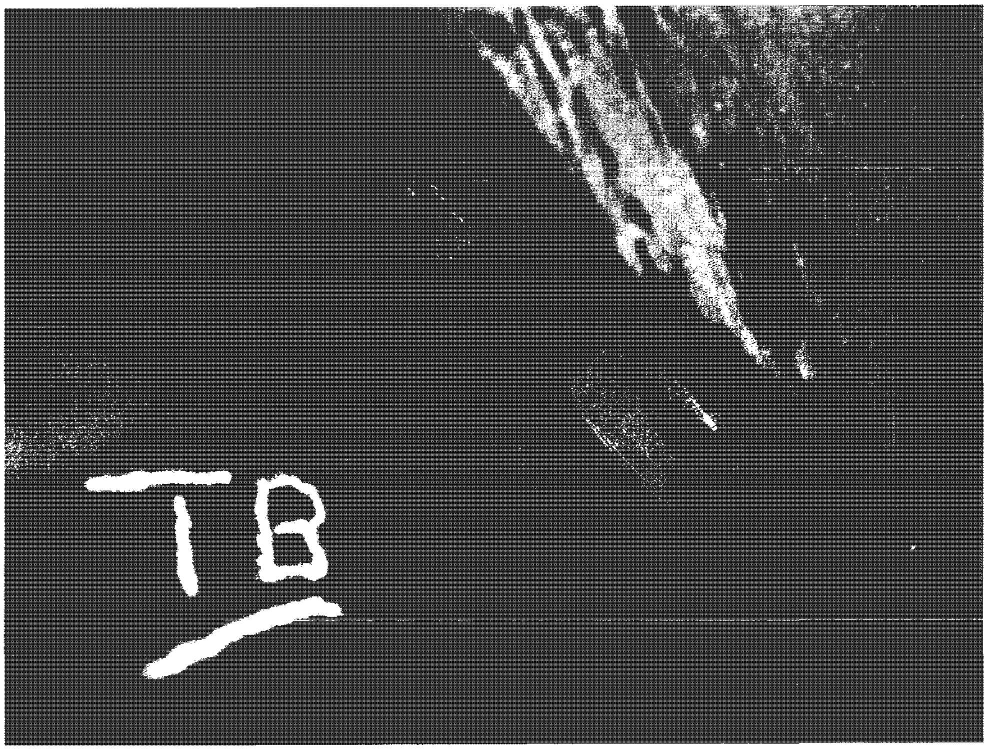


Figure 12-TB Last Stage Bucket with Erosion on Swelled Tenons

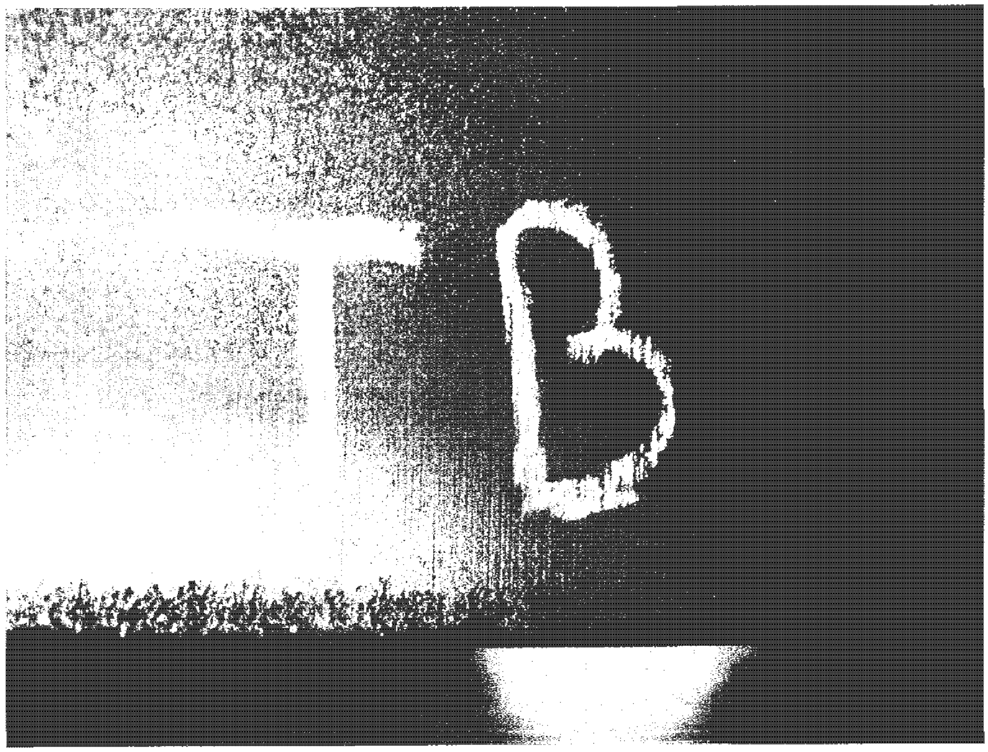


Figure 13-TB Last Stage Bucket with Erosion on Discharge Edge

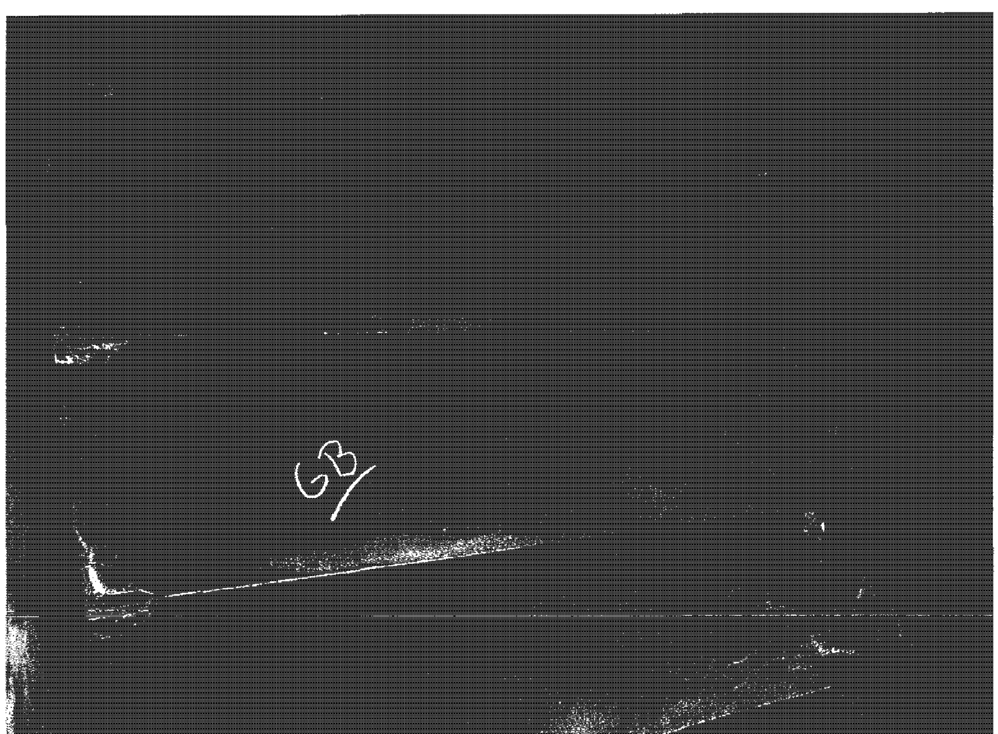


Figure 14-GB Last Stage Buckets

Figure 15-GB Last Stage Buckets with Tip Spill Strip Shown

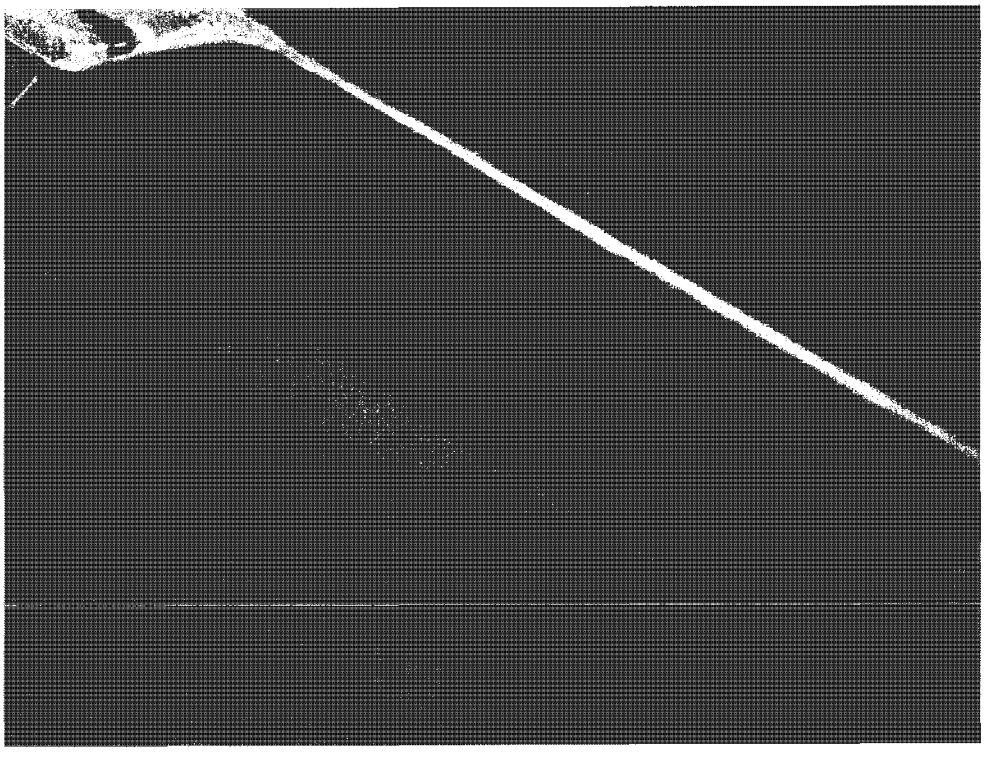


Figure 16-GB Last Stage Bucket with Erosion on Leading Edges of Vane and Cover

IP7019496

Figure 17-GB Last Stage Bucket with Erosion on Swelled Tenons

Figure 18-GB Last Stage Bucket with Erosion on Discharge Edge

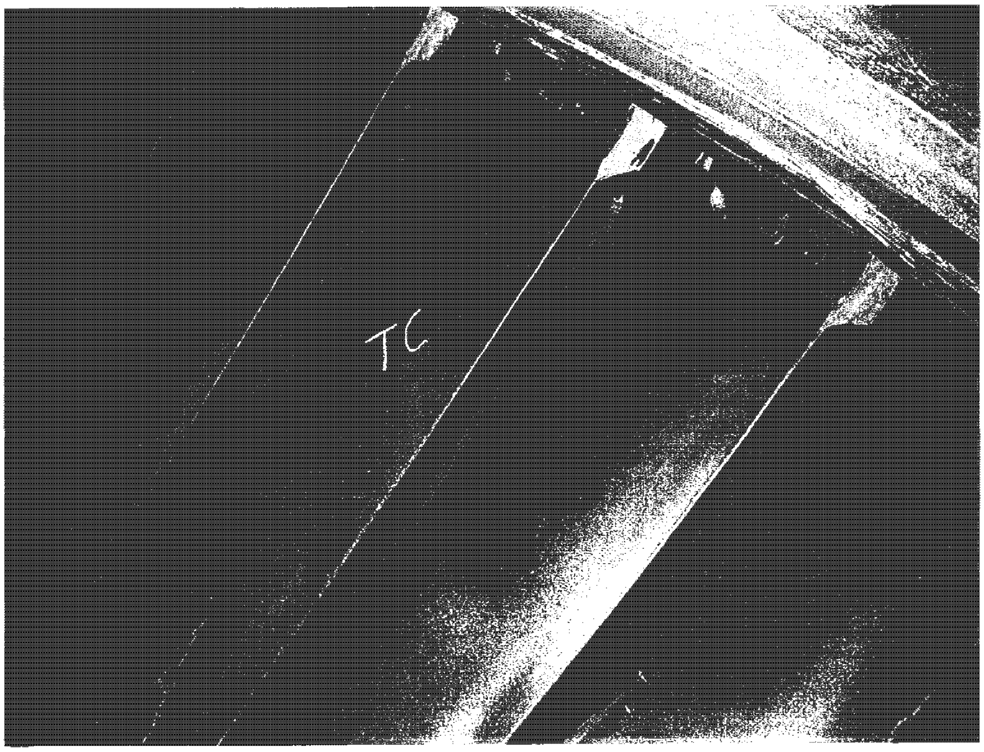


Figure 19-TC Last Stage Buckets

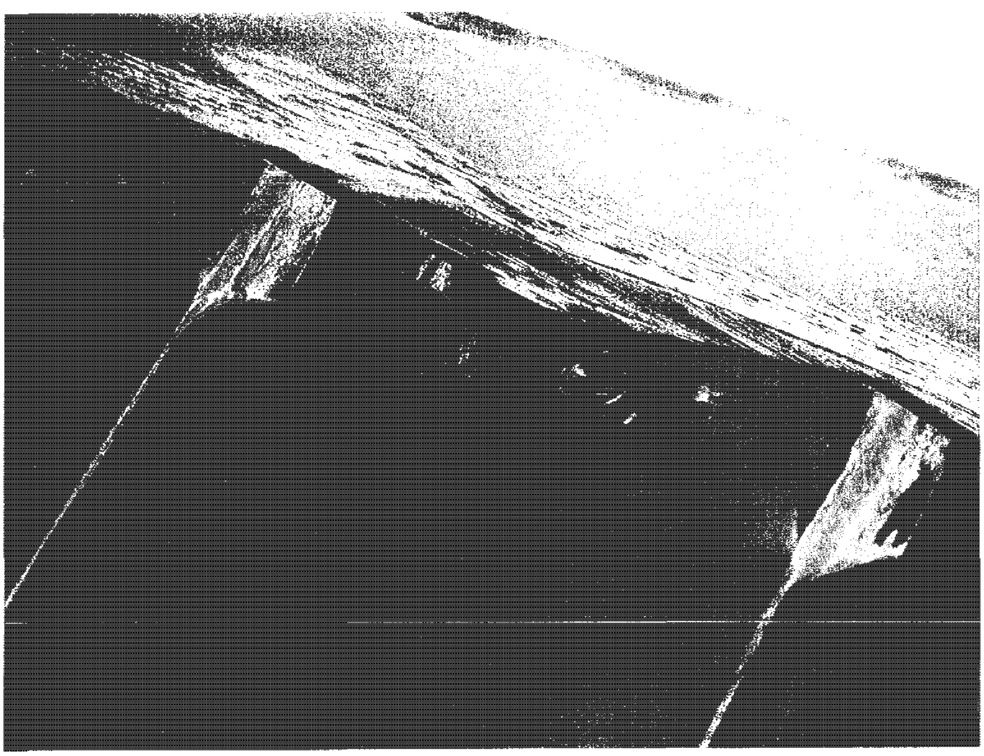


Figure 20-TC Last Stage Bucket Tips

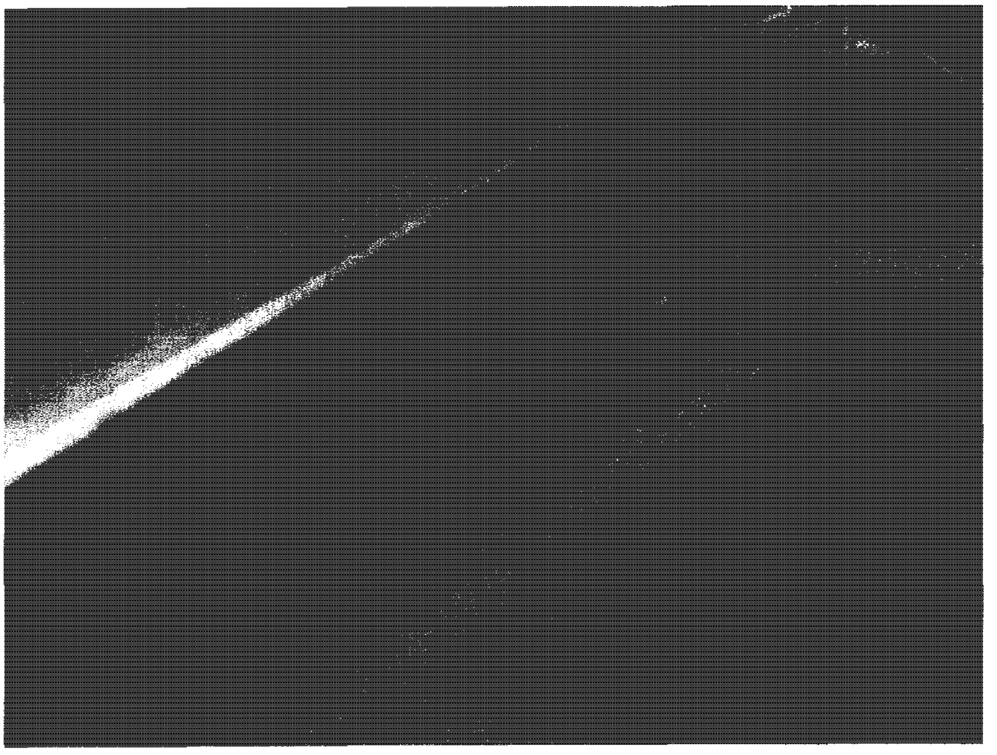


Figure 21-TC Last Stage Bucket with Erosion on Leading Edges of Vane and Cover

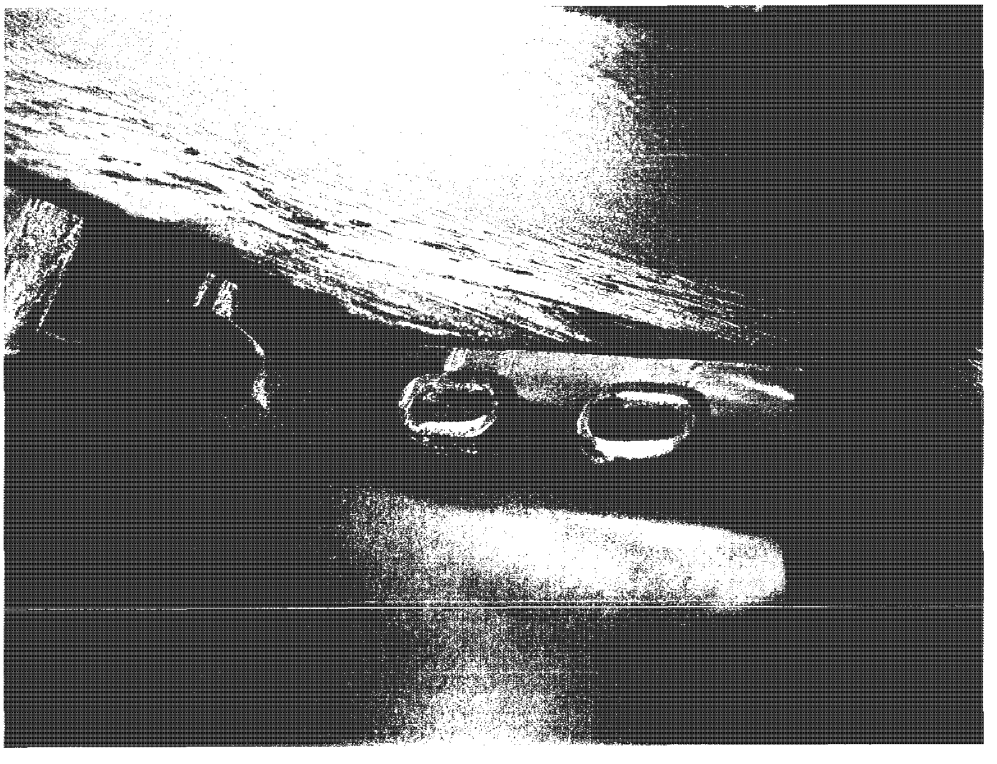


Figure 22-TC Last Stage Swelled Tenons

Figure 23-GC Last Stage Buckets

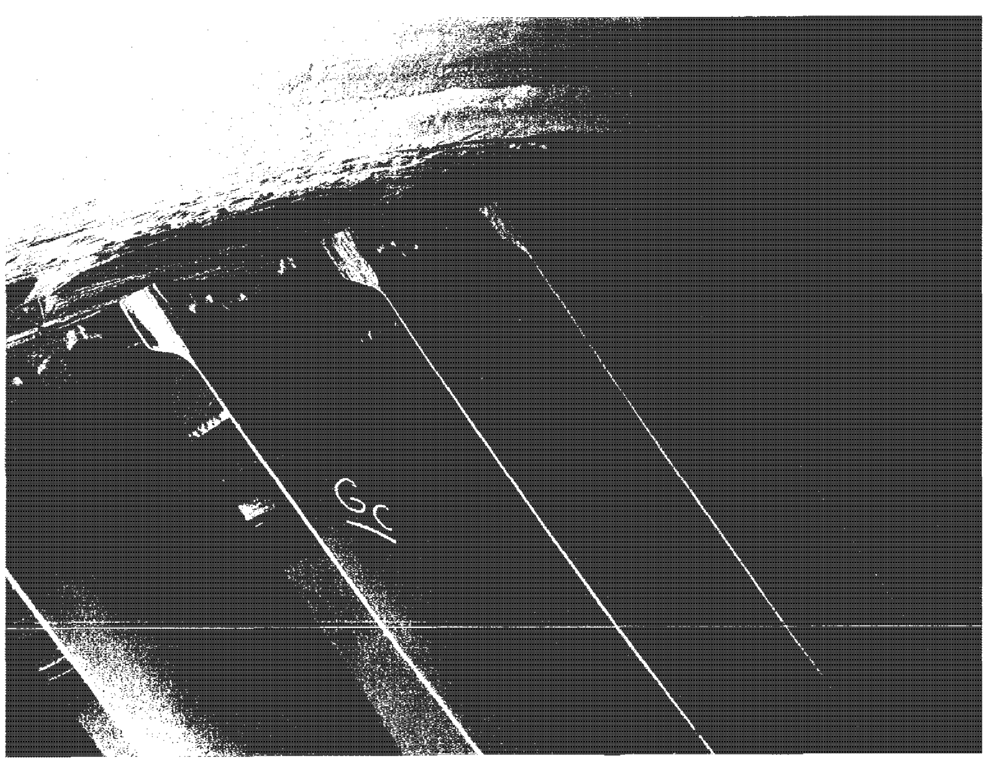


Figure 24-GC Last Stage Buckets with Side Entry Covers

Figure 25-GC Last Stage Bucket Tips

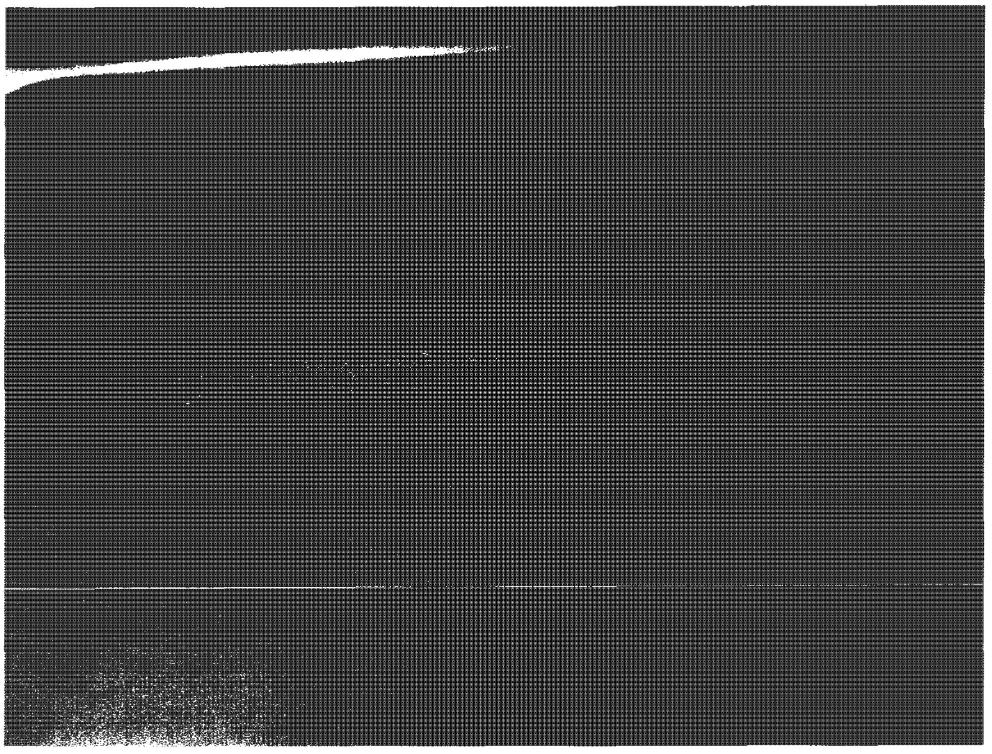


Figure 26-GC Last Stage Bucket with Erosion on Leading Edges of Vane and Cover

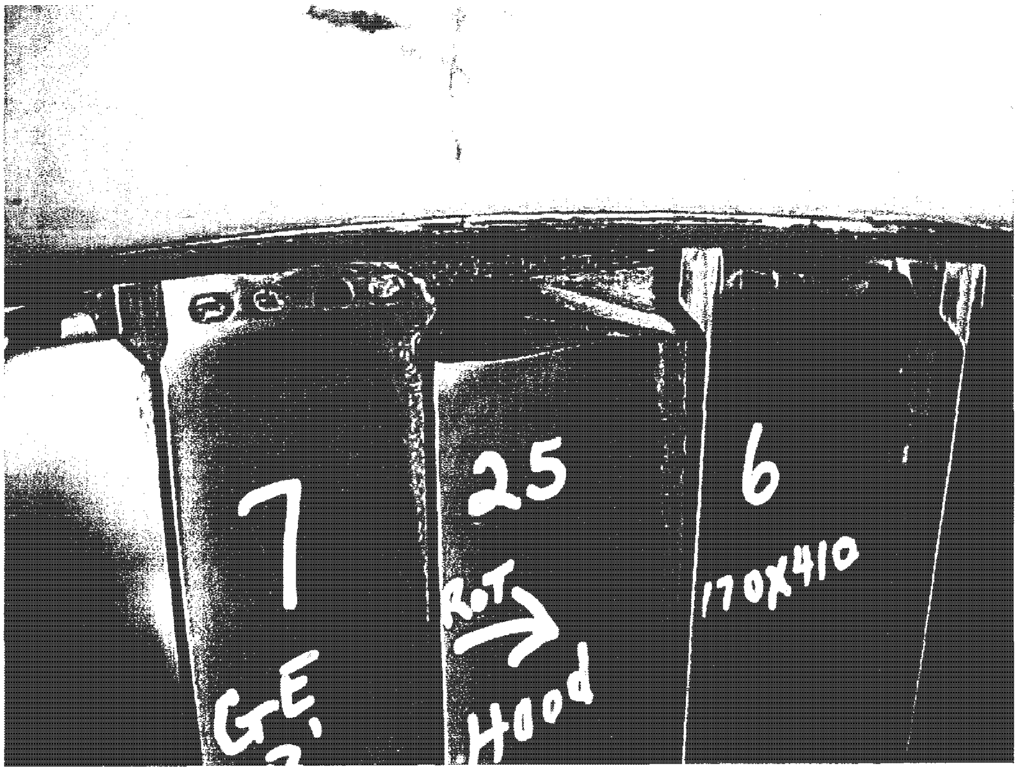


Figure 27-Unshielded 30" Last Stage Bucket with the Tip Missing-Station A

Figure 28-Unshielded 30" Last Stage Bucket with the Tip Missing-Station A

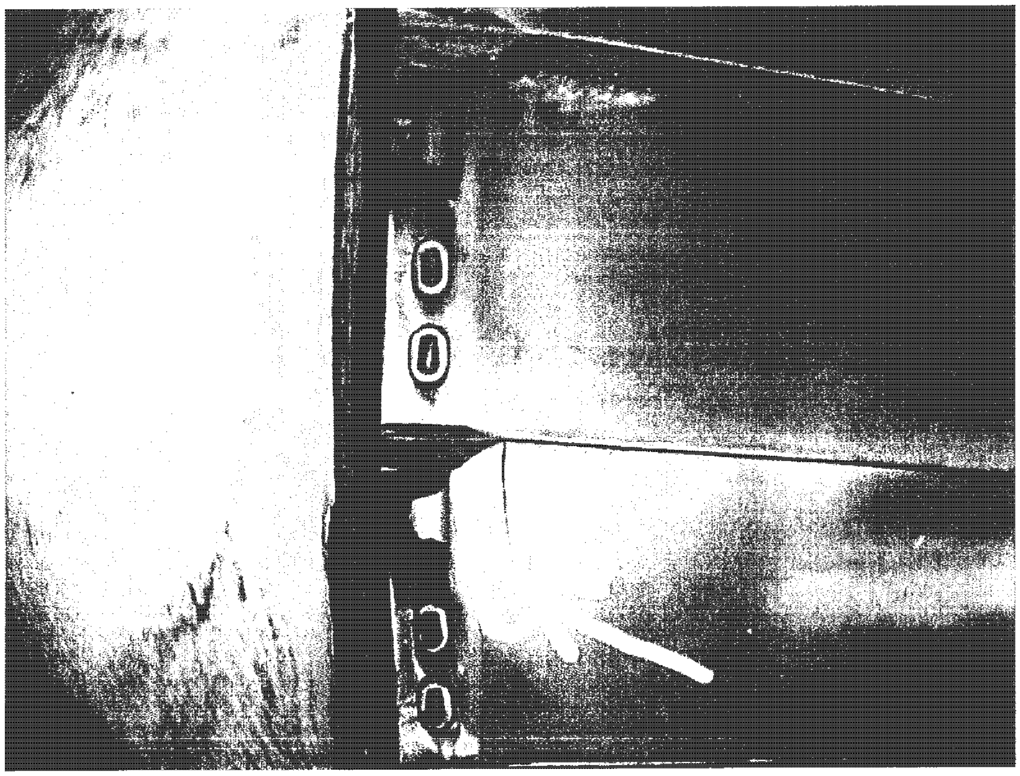


Figure 29-Unshielded 30" Last Stage Bucket with Crack-Station A

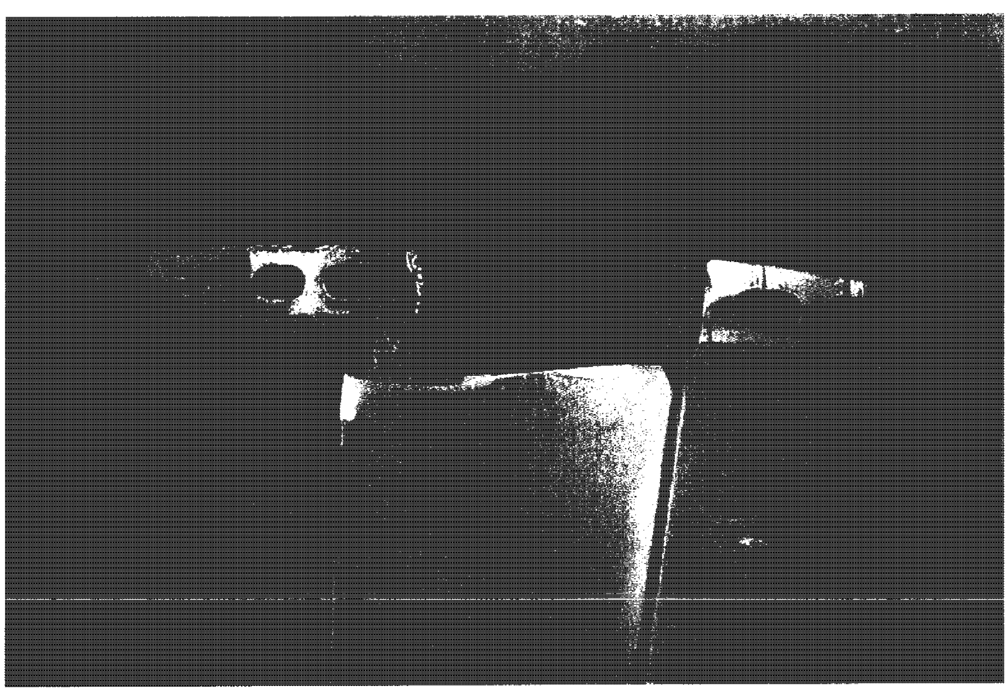


Figure 30-Unshielded 30" Last Stage Bucket with Tip Missing-Station B

MDA and JJs P
4/8

GE L-1
Energy

• Dovetail cracking non-super-
critical units

Alabama Power L-1
Miller 3/4 dovetail end
UT weld repairs
~~24"~~ 2400 psig G3

Miller 3 & 4 89, 92
L1's supercritical 100%
L2's supercritical 50/50

Supercritical TIL more deposits

Excel 30" G3 non. supercritical
• 4 ends cracking w/ Sherco UT
• Sherco 2 didn't have cracks.

* Investigate finite element analysis
on L-1 as precautionary info
if cracks are found this would
help make repair or run decision
• memo to maintenance
•

9th EPRI T-G Workshop
8/22-24/05
Pacificorp 33.5"
TIL 1521-2

p 98-110

EPRI 1014598
Productivity Improvement
for Fossil Steam Power
Plants - info on LSB tip
failures from erosion cracking

110

5 failures for GE (1)

Southern Co 2 failures 30"

Huntington Canyon 33 1/2"

tenons should allow movement

unshielded less tolerant to

Bathtub tenons - overswelled between

'72 first unshielded bucket

'87 complete unshielded

2000 - beyond known life expectancy.

*Bolted spill strip - removes water from steam path

- not excessive erosion

Ameren - 10 yrs + 1 yr 30" G2

— about our erosion (2)

Opinion - ours are much better than the ones that have failed

- Bucket covers { tenons, Bathtub, peened tend } - expanded w 30 mil spacer

allow no tips to move

should see gaps when looking down

GEB - Root TE erosion worse than GEC

TEB — Tenon leading edge erosion

Shrink/Slip cycle - dovetail cracking

> plan in advance for dovetail cracks

(3) i.e. what are we going to do if we get indications from phased array - Need someone to analyze? finite element modeling

ATE - more Root trailing edge erosion - not bad until it gets v-notched.

Alabama power G3's 4 units cracks in all of them

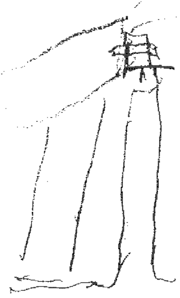
G3 like G2 but 2 IP's

17" L-1 - model excel rejenko

crack propagation ~~length~~ to determine if or how long you can run

finite element analysis/material

Do we need to fix immediately or run for a while ?



MECHANICAL DYNAMICS and ANALYSIS, LTD

29 British American Blvd., Latham, NY 12110 (518) 399-3616
FAX: (518) 399-3929

BUDGET ESTIMATE 70458-B / 70459-B

SUBMITTED TO:

INTERMOUNTAIN POWER AGENCY

DELTA, UNITS 1 & 2

SUBMITTED:

FEBRUARY 6, 2008

MECHANICAL DYNAMICS and ANALYSIS, LTD

MECHANICAL DYNAMICS & ANALYSIS, LTD.
29 BRITISH AMERICAN BLVD., LATHAM, NEW YORK 12110
PHONE: (518) 399-3616 FAX: (518) 399-3929

www.MDAturbines.com

February 6, 2008

BUDGET ESTIMATE 70458-B / 70459-B
Via e-mail

Intermountain Power Agency
850 W Brush Wellman Rd.
Delta, Utah 84624

Attention: Brad Thompson
Outage Planner

Phone: (435) 864-4414
E-Mail: BRAD-T@ipsc.com

Re: ***Units 1 & 2 CCB Installations – April, 2010 & 2011***

Mr. Thompson:

In response to your request via e-mail Mechanical Dynamics & Analysis is pleased to offer the attached Budgetary Estimate for performing the removal and installation of new Hitachi Continuously Covered Blade designs for:

- Purchase of twelve (12) rows of 30" L-0 Continuously Covered Blades (CCB)
- Installation of six (6) rows and low speed rotor balance for multiple LP sections

The work will be completed on-site over the course of two planned outages scheduled for April 2010 and 2011, respectively. MD&A understands the units are GE S2 machines rated originally at 820 Mw with commercial operation beginning in 1986 and 1987, respectively.

MD&A's proposal is organized as follows:

Section 1 – **Pricing**
Pricing, Scope Description and Schedule
MD&A Rate and Rental Schedules

Section 2 – **Technical**
Technical Clarifications
CCB Promotional Material

Section 3 – **Commercial**
Commercial Clarifications
Insurance Certificate - Sample

MD&A appreciates having this opportunity to serve Intermountain Power, and if we get the order, it will be completed in a highly professional manner.

Best regards,

Leo Molina
General Manager- Steam Turbine Retrofits

Cc: MD&A - D Hatcher, A.C. Adam, J Reville, H. Miles, R.C. Allen

Section 1 – Pricing

Pricing, Scope Description & Schedule
MD&A Rate and Rental Schedules

Pricing, Scope Description & Schedule

On-Site Replacement of (12) Rows of L-0 Buckets:

The Proposal includes removal and replacement of the existing buckets with Hitachi Continuously Covered Blades (CCB). The work would be performed on-site at the Delta, UT station.

Low speed balance included

Prices & Delivery:

L-0 30" Continuously Covered Hitachi Blades Installed:

Included On-Site Scope of Work:

1. **Purchase (12) Rows of 30" CCB's for Delivery January, 2010 and Install Six (6) Rows per Outage (April, 2010 & April 2011):**
   Work scope for each LP section outage: Remove six (6) rows of existing 30" last stage buckets and pins by conventional methods using peening guns and up to 15% of the pins via shooting the pins with Hilti guns, installation of new Hitachi 30" CCB's and LP rotor low speed balance.

   a.

Installation Date	Price
April, 2010 – U1 LPA, LPB, LPC	$5,885,605
April, 2011 – U2 LPA, LPB, LPC	$5,885,605
Total Price	**$11,771,210**

   b. Planned Cycle Time for each Project: 33-35 work-days

   Includes 4 days cleaning & NDE after pin removal

Notes:

- **Prices shown are contingent upon purchase of all (12) rows from MD&A/Hitachi and installation by MD&A personnel.**
- **Prices include 88 blades per row plus a maximum of two extra blades for each end and 264 pins plus a maximum of 100 extra pins/row.** 3 pins/blade
- **Un-used extra buckets and extra pins will remain the property of MD&A/Hitachi.**
- **Sizing of the existing blade dovetail pins is to be confirmed at the time of order.**

Most of MD&A's recent finger dovetail installations have not required the shooting of more than 15% of the pins, and required drilling of less than 6 pins per row. MD&A notes, however, that our past success does not guarantee future results. Occasionally a row or rotor is encountered where the pins are difficult to remove as was recently encountered on a unit with saltwater condensers.

Shooting of dovetail pins beyond 15% with a Hilti gun and drilling of pins would be charged as an extra as follows:

Hilti Gun pin removal $185 / per pin; Removal of pins via drilling $650 / per pin

1. We assumed cleaning and NDE of the wheel dovetails after bucket removal would be performed by an Intermountain Contractor(s) already on-site, therefore, costs for these activities are NOT included in our pricing. Our Planned Cycle Time includes 4-days for the blast cleaning and NDE of the rotors performed by others. *
2. Price assumes that all L-0 dovetail pins can be removed by conventional removal using peening guns plus shooting up to 15% of the pins using the Hilti guns. Any machining to remove the buckets will be considered an extra.
3. Bucket removal, wheel dovetail inspection, installation and final machining will be super-

IP7019509

vised by a MD&A Steampath Engineer. All of MD&A's Steampath Engineers are OEM trained and have a minimum of 20-years of turbine-generator experience

4. Low speed balance of the rotors includes a balance machine, Balance technician and supervision of a MD&A Balance Engineer.

Hitachi CCB Delivery:

Hitachi is manufacturing L-0 Continuously Covered Buckets (CCB's) for stock, owner replacement purchases as well as new units all of the time. Typical delivery from receipt of order is 12 to 14 months.

Advantages of Hitachi 30" L-0 Continuously Covered Blades (CCB's)

As noted, the new 30" CCB L-0 buckets which is identical to the 33.5" CCB except, of course, for vane length and pins will be supplied by Hitachi which has designed and manufactured GE design turbines for over 30 years. This includes the manufacture of 30" L-0 DFLP turbine rotors and buckets of the type currently installed at Intermountain Power. Double flow

The Hitachi CCB L-0 buckets, first installed in 1991 and currently with over two hundred thirty (230) rows in service, have numerous advantages:

The Hitachi 30" CCB offers several distinct advantages which improve reliability:

- Mono-Block blade design *eliminates* the separate side-entry covers which are thought to be one of the potential sources for recent forced outages due to 30" LSB failures. With its ***integral Interlocking "Z-Lock" cover and mid-span tie-boss*** it *eliminates flaring the tenons and "nubs and sleeves.*

- Virtually eliminates areas where deposits can form thereby making the blade *much less susceptible to stress corrosion cracking (SCC).*

- The re-designed transonic blade profile results in:
  - *Stage efficiency increase of 0.8%*
  - *Ability to operate above 50% load at higher backpressure limits*
    - *Alarm set at 7.5" and Trip set at 9" Hg*
  - *Significantly reduced blade stress levels.*

- The vane design includes an Inconel-welded formed stellite erosion nose on the bucket leading-edge which addresses one of the failure concerns regarding the current "unshielded" blade design incorporated by the OEM – see the enclosed for descriptions of the Hitachi erosion shield configuration.

- A single bucket can be replaced without having to remove other buckets in the row.

  Thus if a bucket is damaged during unit disassembly, impacted by foreign material during operation or experiences some other operational problem, a bucket can be replaced by knocking out just (6) dovetail pins

- The new Hitachi 30" L-0 CCB's blade offers *excellent vibration characteristics.*

  The design natural frequencies were determined by Hitachi using finite element methods and then the analytical results were confirmed by wheel box testing a row of buckets at running speed. In addition, Hitachi's manufacturing plan includes a single bucket standing vibration test to ensure production rows of buckets do not deviate from the original design. Lastly the blade vibration characteristics has been analyzed by a recognized independent technical group (TTI in Rochester, NY) and determined to be a good replacement for the OEM blades.

- Finally, the CCB designs are *Drop-in replacement* for the existing buckets, with *no modifications* required to the existing wheel dovetails or diaphragms.

As stated above the first row(s) of Hitachi CCB L-0 bucket designs entered service in 1991. There are over (230) rows in service world-wide, including the twenty-seven (27) rows installed by MD&A in North America since May 1999. In addition, Hitachi installed eight (8) rows in eastern Canada in 2004. No operational problems have been reported with any of these installations.

The attached Hitachi CCB literature provides additional information on these benefits. MD&A's Commercial Clarifications, Technical Clarifications and 2007 Published Rate Schedule are also attached. The rate schedule, Commercial and Technical Clarifications in effect at the time of purchase order placement, will apply.